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# **A Study of Babylonian Goal-Year Planetary Astronomy**

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PhD Thesis

Department of Physics  
University of Durham  
2009

## Abstract

Throughout the Late Babylonian Period, Mesopotamian astronomers made nightly observations of the planets, Moon and stars. Based on these observations, they developed several different techniques for predicting future astronomical events. The present study aims to improve our understanding of a particular empirical method of prediction, which made use of planetary periods – a period of time over which a planet’s motion recurs very closely – to predict that planet’s future motion.

Various planetary periods are referred to in many Late Babylonian astronomical texts. By collecting together these periods and analysing their effectiveness, it was found that, generally, the most effective of the planetary periods were those which were used in the production of a particular type of text known as a Goal-Year Text. The Goal-Year Texts contain excerpts of astronomical observational records, with the planetary records having been taken from particular observation years with these planetary periods in mind – such that each planet’s motion will recur during the same, specific, future year. It has been suggested that they form an intermediate step towards the compilation of the non-mathematical predictive texts known as Almanacs and Normal Star Almanacs.

An analysis of theoretically calculated dates of planetary events showed that, if the Goal-Year Texts were to be used as a source for making empirical predictions, particular corrections (specific to each planet) would need to be applied to the dates of the planetary records found in the Goal-Year Texts. These corrections take the form of regular corrections to the day of an event (a “date correction”), and more irregular corrections of  $\pm 1$  month (a “month shift”). An extensive investigation of the Babylonian non-mathematical texts demonstrated that the observed differences in the dates of events, when comparing equivalent records in all known extant Almanacs and Normal Star Almanacs with those in the Goal-Year Texts, were extremely consistent with theoretical expectations. This lends considerable support to the theory that the Goal-Year Texts’ records formed the “raw data” used in the compilation of the Almanacs and Normal Star Almanacs.

It was also possible to analyse several other aspects of Late Babylonian non-mathematical astronomy during the course of this study. These topics include the usage of particular stars in the predictive texts, the meaning of certain terminology found in records of the Babylonian zodiacal signs, and the specific issues related to the planet Mercury’s periods of visibility and invisibility. Therefore, this investigation enhances many aspects of our knowledge of Late Babylonian astronomical practices.

## Declaration

The work described in this thesis was undertaken between 2006 and 2009 while the author was a research student under the supervision of Professor John Steele in the Department of Physics at the University of Durham. This work has not been submitted for any other degree at the University of Durham or any other University.

Portions of this work have appeared in the following papers:

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# Chapter 1

## Introduction

### 1.1 General Introduction

The origins of several aspects of modern western astronomy are found in the astronomical practices developed 2000-3000 years ago in the region of Mesopotamia. Concepts which were first used in Mesopotamia, such as sexagesimal number systems, still form part of our everyday lives.<sup>1</sup> Various elements of Mesopotamian astronomical knowledge spread to other regions, by communication with astronomers from Greece and other cultures.<sup>2</sup>

The vast majority of extant Mesopotamian astronomical texts date to the Late Babylonian Period (the period between approximately 750BC – 75AD), mostly from the city of Babylon (with a much smaller number from the city of Uruk). We can divide the astronomical texts from this period into three (interconnected) areas – non-mathematical observations and predictions, mathematical predictions, and astrology/horoscopes – which shall be described in detail later.

The main aim of this study is to understand the relationship between the various types of texts which are classed as non-mathematical. In particular, my goal is to understand the uses of one of the classifications of non-mathematical text: the Goal-Year Text.<sup>3</sup> Chapter 2 describes the different classifications of non-mathematical text from the period and their contents in detail and, as we shall see, Goal-Year Texts are divided into sections which each consist of observations relating to a particular planet (or to the Moon) from a particular year. Note that the scope of this work is to investigate the textual relationships by study of the *planetary* observations and predictions; as we shall see later, observations and predictions of lunar events have been thoroughly investigated in recent years (see §1.3.2.2), against the comparatively lower attention which the non-mathematical planetary records have attracted. Therefore in this work my focus will always be concerning the planetary rather than the lunar records.

The motion of the planets is extremely periodic, and so a given planet's motion will recur an (approximately) exact number of Babylonian years later. Therefore the Goal-Year Texts copy observational planetary records from particular years, to make use of these planetary periods (which will of course be different for each planet). The years chosen are such that during a specific future year (known as the goal year), each of the planets will have exactly completed a period over which its motion recurs.

In other words, an approximate record of events for the goal year can be predicted empirically by being aware of periods over which planetary events recur, and extracting specific observational records from those years accordingly. This non-mathematical method of making empirical predictions may also be referred to as “Goal-Year astronomy”; even though the Goal-Year Texts themselves are not found until the late 3<sup>rd</sup> century BC, these Goal-Year type empirical methods of prediction are observed across the entire Late Babylonian Period, from the earliest extant texts. Chapter 4 collects together the

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<sup>1</sup> For general overviews of Mesopotamian astronomy and its legacies, see for example Neugebauer (1969), Pingree (1998), Steele (2008).

<sup>2</sup> Various aspects of this knowledge transfer (both to and from Mesopotamia) are discussed in, for example, Neugebauer (1963 and 1989), Jones (1991), Toomer (1988), Steele (2007c).

<sup>3</sup> The names and classifications of the non-mathematical texts are explained in Sachs (1948).

planetary periods recorded in these texts, and investigates ways we could determine how effective the planetary periods were in practice.

It has been suggested that the Goal-Year Texts form the “raw data” from which the non-mathematical predictive texts were produced – this theory is analysed in depth in Chapters 5 and 6. As we shall see, Goal-Year planetary astronomy has generally attracted somewhat less attention than other aspects of Late Babylonian non-mathematical or mathematical astronomy (which will be outlined later in the chapter).

The fact that each planet’s records in a Goal-Year Text date to a different observations year, and that these years relate to the planets’ periods of motion, was discovered in some of the earliest investigations of these texts. This knowledge is referred to in some of the earliest studies of Babylonian astronomy by Epping<sup>4</sup> and Kugler<sup>5</sup> (who calls the Goal-Year Texts “planetarischen Hilfstafeln”).

In Sachs’ *Classification of the Babylonian Tablets of the Seleucid Period* he gives the Goal-Year Texts, along with the other types of non-mathematical texts, their current name, and considers at length what the source of the records in the various non-mathematical predictive texts may have been.<sup>6</sup> He suggests, and discusses the problems associated with, several potential sources, described below:

- i) that the predictive records come from the ephemerides in the “Astronomical Tables” (i.e. what we would now call the *Astronomical Cuneiform Texts (ACT)*<sup>7</sup> – see §1.3.3 for a description of these),
- ii) that the predictive records come from the observational records in the Goal-Year Texts (of uncertain source themselves),
- iii) that both of the above sources together were used in the production of the non-mathematical predictions,
- iv) that the predictive texts known as Normal Star Almanacs used the Goal-Year Texts, and the predictive texts known as Almanacs used the *ACT* data.

Each of these suggestions will be analysed in the following chapters.

More recent researchers have tended to agree with Sachs’ assessment of the predictive texts’ potential sources. Hunger states that the types of records in the Goal-Year Texts and the predictive texts could well have come from the same source.<sup>8</sup> However, he compares records in the Goal-Year Texts and the predictive texts and finds a considerable number of differences, showing that even if there exists a relationship between these texts, it is not as simple as just copying the records across. As Chapters 4 and 5 will discuss, we would expect these differences to be found.

Conversely, Hunger & Pingree point out the differences between the contents of the Goal-Year Texts and the predictive texts, suggesting that “no one of them derives from another”.<sup>9</sup> The main difference they find between the text types’ contents seems to be that the predictive texts contain computed dates of, eg, solstices and eclipses and the Goal-Year Texts do not. However, since these dates were always computed according to a particular scheme, as we shall see in Chapter 2, this does not cast doubt on the possibility of Goal-

---

<sup>4</sup> Epping (1889).

<sup>5</sup> Kugler (1907), p 19 and pp 84-87.

<sup>6</sup> Sachs (1948), pp 287-290.

<sup>7</sup> Neugebauer (1955).

<sup>8</sup> Hunger (1999).

<sup>9</sup> Hunger & Pingree (1999), p. 173.

Year Texts’ uses in predicting planetary events. Hunger & Pingree’s point is presumably also that the records in the extant predictive texts could not have come from the records in the extant observational texts, but we must surely assume that the number of texts available to the Babylonian astronomers must be considerably higher than the number which have survived to the present day. See Figure 2.1 in the following chapter for an illustration of the relatively low numbers of non-mathematical text extant nowadays.

In his introduction to the recent volume of translations of Goal-Year Texts, Hunger agrees with this suggestion that specific records may have derived from texts which were available to the Babylonian astronomers but which have not yet been excavated and become available to us, or which have been destroyed. He also agrees with Sachs that the Goal-Year Texts’ purpose must have been “obvious: to make predictions for the Goal year”.<sup>10</sup>

Most recently, Steele has considered *Goal-Year Periods and Their Use in Predicting Planetary Phenomena*.<sup>11</sup> In this paper, he discusses the use of the planetary periods in the Goal-Year Texts, and in other texts, to predict planetary events. He also discusses the corrections which need to be applied to the planetary periods, in terms of days or degrees of longitude, to allow for the fact that the planets’ periods are not necessarily an exact number of Babylonian years long.<sup>12</sup> Chapters 4 and 5 will analyse these date corrections.

## ***1.2 Calendars and chronology***

### **1.2.1 Mesopotamian chronology**

The point marking the beginning of the Late Babylonian Period is commonly taken to be the accession of Nabonassar in 747 BC. Ptolemy uses this date as the beginning of his “Canon of Kings”<sup>13</sup> and states that the Babylonian observations he uses in the *Almagest* begin from Nabonassar’s reign.<sup>14</sup> Mesopotamian texts generally record dates by the use of regnal years, i.e. the number of years since the current king came to the throne. Without independent corroboration of the dates of a king’s reign (or by means of a dateable astronomical or historical event) it can be extremely difficult to ascertain when exactly a text was written in terms of our present-day BC-AD calendar, and this has led to the dates of entire periods of history being disputed.

Fortunately, the dates of kings’ reigns during the Late Babylonian Period are considered secure. This is due in a large part to Ptolemy’s “Canon of Kings”, which lists the names of all the Late Babylonian kings, along with the length of their reign and the total number of years between their reign and Nabonassar’s accession in each case.<sup>15</sup>

A summary of the Late Babylonian Period’s chronology is given in Table 1.1. The table shows the names, lengths of reigns, and date of the first year of each reign for kings during the period. From Nabopolassar onwards the names and dates are taken from Parker & Dubberstein’s chronological tables, and before this point the names and dates are taken from J. A. Brinkman’s “Mesopotamian Chronology” and Ptolemy’s Canon of Kings.<sup>16</sup> It can be seen from the Table that Parker & Dubberstein’s dates occasionally include overlapping reigns of kings or multiple accessions in the same year, presumably due to

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<sup>10</sup> Hunger (2006), p. XII.

<sup>11</sup> Steele (2009, in press).

<sup>12</sup> See also Gray & Steele (2008).

<sup>13</sup> Depuydt (1995).

<sup>14</sup> *Almagest* III.7, translated in Toomer (1998), p. 166.

<sup>15</sup> Depuydt (1995), Hallo (1988). See also Walker (1999).

<sup>16</sup> Parker & Dubberstein (1956), Oppenheim (1964) p. 340, Toomer (1998) p. 11.

disputes about who the new monarch should be. Ptolemy's Canon does not include the details of these contests.

Note that Babylonian years begin and end in March or April of our calendar, so each Babylonian year will span part of two BC years. To reduce ambiguity, in the table I have given both BC years covered by the Babylonian year. Note also that kings' names are not listed in the table from 311 BC onwards because from that point the texts were not dated according to the current ruler, but according to the number of years since Seleucus I's accession in 311 BC. Once Babylon became part of the Parthian Empire in the mid-2<sup>nd</sup> century BC, dates were given according to the Arsacid Era (number of years since 247 BC) in addition to the Seleucid Era dates.

| Empire         | King                 | First year of reign (BC) | Years of reign |
|----------------|----------------------|--------------------------|----------------|
| Neo-Assyrian   | Nabonassar           | 747/746                  | 14             |
|                | Nabu-nadin-zeri      | 733/732                  | 2              |
|                | Nabu-šuma-ukin II    | 732/731                  | < 1            |
|                | Nabu-mukin-zeri      | 731/730                  | 3              |
|                | Tiglath-Pileser/Pulu | 728-727                  | 2              |
|                | Shalmaneser/Ululaju  | 726/725                  | 5              |
|                | Marduk-apla-iddin    | 721/720                  | 12             |
|                | Šarru-ukin           | 709/708                  | 5              |
|                | Interregnum          | 704/703                  | 2              |
|                | Bel-ibni             | 702/701                  | 3              |
|                | Aššur-nadin-šumi     | 699/698                  | 6              |
|                | Nergal-ušezi         | 693/692                  | 1              |
|                | Mušezi-Marduk        | 692/691                  | 4              |
|                | Interregnum          | 688/687                  | 8              |
|                | Ašur-aḫa-iddina      | 680/679                  | 13             |
|                | Šamaš-šum-ukin       | 667/666                  | 20             |
|                | Kandalanu            | 647/646                  | 22             |
| Neo-Babylonian | Nabopolassar         | 625/624                  | 21             |
|                | Nebuchadnezzar II    | 604/603                  | 43             |
|                | Amel-Marduk          | 561/560                  | 2              |
|                | Nergal-Shar-Usar     | 559/558                  | 4              |
|                | Labashi-Marduk       | 556/555                  | < 1            |
|                | Nabunaid             | 555/554                  | 17             |
| Persian        | Cyrus                | 538/537                  | 9              |
|                | Cambyzes             | 529/528                  | 8              |
|                | Bardiya              | 522/521                  | < 1            |
|                | Nebuchadnezzar III   | 522/521                  | < 1            |
|                | Nebuchadnezzar IV    | 521/520                  | < 1            |
|                | Darius I             | 521/520                  | 36             |
|                | Xerxes               | 485/484                  | 21             |
|                | Artaxerxes I         | 464/463                  | 41             |
|                | Darius II            | 423/422                  | 19             |
|                | Artaxerxes II        | 404/403                  | 46             |
|                | Artaxerxes III       | 358/357                  | 21             |
| Macedonian     | Arses                | 337/336                  | 2              |
|                | Alexander III        | 336/335                  | 14             |
| Persian        | Darius III           | 335/334                  | 5              |
| Macedonian     | Philip Arrhidaeus    | 323/322                  | 8              |
|                | Alexander IV         | 316/315                  | 10             |
|                | Seleucid Era         | 311/310                  | onwards        |

**Table 1.1: the names and regnal dates of rulers of Babylon during the Late Babylonian Period.**

### 1.2.2 Calendrical systems

The basic unit of the Mesopotamian calendar was the lunar month. The first day of a new month was marked by the first visibility of the new lunar crescent at sunset, which provided an easily-observable way to document the passage of time.<sup>17</sup> However, the synodic month is approximately 29.53 days long on average, and therefore lunar months varied between 29 or 30 days long in no particularly regular sequence, making some administrative functions unnecessarily complex. It has been shown that, from around 2600 BC to 300 BC, there were therefore *two* calendrical systems in use simultaneously: the civil calendar, based on the lunar month; and the administrative calendar, based on ideal months which were always 30 days long.<sup>18</sup> The Late Babylonian astronomical texts always use the lunar calendar, denoting the different month lengths by stating whether each new month began 29 or 30 days after the previous one.<sup>19</sup>

Another complication of the lunar calendar is that there are not a whole number of lunar months in a solar year, leading quickly to a lack of connection between calendar dates and seasons. Some cultures had very successful calendrical systems where there was no association between time of year and calendar dates or months, and did not seem to mind that lack; for example, the calendar devised by the Egyptians, whose calendar year invariably had 365 days, was still in use in the Middle Ages.<sup>20</sup> However, in Mesopotamia the preference was for the new year to begin around the time of the vernal equinox. Twelve lunar months contain approximately 354 days, around eleven days short of a solar year. Therefore, from the 3<sup>rd</sup> millennium BC, an extra month was inserted into the Mesopotamian calendar every three years or so to keep the months and the seasons in step.<sup>21</sup>

Initially an intercalary month would be added into the calendar at any point of the year where it was deemed to be needed, but gradually intercalation schemes evolved. Around 480 BC the Metonic Cycle was introduced, which adds 7 intercalary months into specific years on a 19-year cycle.<sup>22</sup> This highly accurate intercalation scheme was used without alteration for the rest of the period. (Despite being named after a Greek philosopher, Meton of Athens, the 19-year cycle was in use in Babylonia first.<sup>23</sup>)

With these two pieces of information – a confirmed chronology of dates of reigns (or starting date of an era) and the calendrical system in use at the time, it is possible to convert any Late Babylonian date into a date in the more modern Julian calendar. For example, Parker & Dubberstein's<sup>24</sup> conversion tables show the equivalence of dates in the two systems for years between 626 BC (the start of the Neo-Babylonian empire) and 75 AD. The two major caveats with using the dates from these tables are: firstly, that any conversion may be wrong by  $\pm 1$  day when the tables incorrectly designate a month as full or hollow. Secondly, the tables generally follow the same 19-year sequence of intercalary months throughout the whole period, even though this sequence became fixed only around

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<sup>17</sup> As Britton (2007a), p. 130 remarks, month lengths recorded in the texts show that the criterion was first *visibility* of the lunar crescent rather than the subtly different first *observation* (which would lead to much longer months during periods of bad weather). Steele (2007b) shows that during the Seleucid Era the first day of a new month was always calculated in advance.

<sup>18</sup> Englund (1988), Brack-Bernsen (2007).

<sup>19</sup> Sachs & Hunger (1988), p. 20. The conventional terminology refers to 29-day months as “hollow” and 30-day months as “full”.

<sup>20</sup> Neugebauer (1969), p. 81.

<sup>21</sup> Britton (2007a).

<sup>22</sup> Britton (2002).

<sup>23</sup> Bowen & Goldstein (1988).

<sup>24</sup> Parker & Dubberstein (1956).

480BC. This means that they occasionally erroneously include an intercalary month in a particular year where the textual evidence shows that it did not occur that year, but in the previous or following year.<sup>25</sup> In terms of dating events, there would simply be a disconnection of exactly a month between Parker & Dubberstein's dates and actual Babylonian dates, for the period between the expect intercalary month and the actual intercalary month, which would need to be taken into account.<sup>26</sup>

As previously stated, many cuneiform texts have become damaged in the intervening millennia since they were written. This leads to the fact that in many cases the date of a text has broken away, since the date tends to be recorded at the very beginning or end of the text. However, some of the time the date of even a broken text can be estimated or deduced. Firstly, the style of writing or the use of particular terminology will often demonstrate whether the text is from earlier or later periods of cuneiform history (although this will not in itself distinguish an old text from a later copy of an older text).

Secondly, astronomical or historical records on the texts can be analysed. A historical event corroborated by other sources, such as the death of Alexander the Great,<sup>27</sup> can yield a date, though this is comparatively rare. Much more common is dating a text by means of the astronomical positions and events. Naturally, planetary, lunar or solar phenomena tend to be periodic and so will not individually supply a unique date, but a number of events for the same month, say, will very quickly reduce the number of possible solutions.<sup>28</sup> The ease of finding a unique solution is improved by a record of a relatively rare event, such as a solar eclipse or an observation of Halley's comet.<sup>29</sup> The date of a Sirius date, an equinox or a solstice will also reduce the possible dates to one year in 19 because dates of these events were predicted on a 19-year scheme rather than being observed.<sup>30</sup>

One final note on the dating of texts: it is often difficult to know how to refer to Babylonian years (which span more than one Julian year, as we have seen) unambiguously. The terminology "747/746 BC" is unambiguous but can be cumbersome, and referring to, say, "Year 1 of Nabonassar" is not completely clear unless one is otherwise aware of the dates of the kings' reigns. A conventional way of referring to BC dates is to create a continuous sequence of years by referring to the year 1 BC as year 0, then the year 2 BC as -1, and so on; the first year of Nabonassar's reign, for example, would be the year -746/-745 in this terminology. The continuous sequence of years simplifies modern calculations involving ancient dates, although the terminology is not much less cumbersome than using BC dates.

Once the Seleucid Era begins, the Babylonian astronomers conventionally record the dates of all their texts according to the year of the era rather than by kings' reigns. This means that to establish the chronology of the Seleucid Era one only needs independent confirmation of one date (the starting point of the era, i.e. the accession of Seleucus I in 311 BC) rather than needing to be aware of the regnal dates of every ruler. From this point

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<sup>25</sup> See for example Britton (2007b), or the commentary to *ADART* Vol. V No. 59. (When making reference to a particular text translated by Sachs & Hunger (1988-2006), I will hereon refer to it as *ADART* Vol. m No. n).

<sup>26</sup> For more on the addition intercalary months and how this affects astronomical predictions, see Chapter 6.

<sup>27</sup> Laconically recorded by the Late Babylonian astronomers in *ADART* Vol. I No. -322B, Obv. 8: "The 29<sup>th</sup>, the king died".

<sup>28</sup> For a general discussion on dating texts, see Sachs & Hunger (1988), p. 19. A specific method of accurately dating texts based on sequences of lunar data has been devised by Huber, detailed in Huber & Britton (2007), Huber & Steele (2007).

<sup>29</sup> Stephenson & Walker (1985).

<sup>30</sup> Neugebauer (1948), Sachs (1952b). This is discussed further in the following chapter.

the difficulty of writing Babylonian years clearly and unambiguously is largely solved by giving the date of Seleucid Era texts as year “SE Y”. Therefore I shall follow this terminology where possible.

### **1.3 Late Babylonian Astronomy**

#### **1.3.1 Overview of the development of astronomy in Mesopotamia**

Let us now move on to the specific astronomical interests of the Late Babylonian scribes. As mentioned above, these fall into three main areas: non-mathematical astronomy, mathematical astronomy, and horoscopic astrology. First we shall briefly put the Late Babylonian astronomy and astronomers in context by looking at the development of astronomy in earlier periods of Mesopotamian history, particularly the long tradition of interpreting planetary omens.

It is not known exactly when occurrences such as unusual weather conditions or astronomical events began to be seen as messages from the gods in need of interpretation. The earliest records of such omens date from the early second millennium BC,<sup>31</sup> and their compilation into the vast omen collection *Enūma Anu Enlil* seems to have happened during the Middle Assyrian Period, in the early first millennium BC.<sup>32</sup> *Enūma Anu Enlil* consists of around 70 tablets, containing some 6000-7000 omens. The omens’ format typically includes an “if” statement (the “protasis”) involving events of the Moon, Sun, planets, stars or the weather, and a “then” statement (the “apodosis”) determining the consequences to the king or the nation based on the event. Some texts also outline rituals which can be undertaken to ward off the effects of inauspicious omens.<sup>33</sup>

Concurrent with the compilation of these omen texts, we also find the rise of star catalogues. One of the earliest surviving examples, the *Three Stars Each*, dates to around 1100 BC. It divides the sky into three regions, assigning all the stars within a region to the god Enlil, Anu or Ea.<sup>34</sup> A later text which also contains a star catalogue is MUL.APIN, believed to have been compiled from records dating from around 1300 BC.<sup>35</sup> Many copies of MUL.APIN exist from across the entire Neo-Assyrian period, and it was being recopied as late as the Seleucid Era;<sup>36</sup> clearly, MUL.APIN was regarded as a significant text. It contains many astronomical and astrological sections, including a star catalogue, information on stars’ heliacal risings, calendrical intercalation schemes and some omens.

By the 10<sup>th</sup> century BC Assyria became a dominant power in Mesopotamia and, in the 8<sup>th</sup> century BC, conquered Babylonia. From this period we find textual evidence that the king had in his service a number of scholars who were expected to report on and interpret ominous events. A large body of letters and reports were found in Nineveh’s royal archives, written by scholars in Nineveh and in other cities around the region, and addressed to the king. Many of the texts are astrological in nature, often quoting a relevant omen from *Enūma Anu Enlil* in their reports – thus showing that *Enūma Anu Enlil* remained an important reference text during the Neo-Assyrian period, several hundred years after its compilation.<sup>37</sup>

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<sup>31</sup> Steele (2008), p. 31.

<sup>32</sup> Many of the tablets are translated and discussed in, variously, Reiner & Pingree (1981), Rochberg-Halton (1988a), van Soldt (1995).

<sup>33</sup> Hunger & Pingree (1999), pp. 5-26.

<sup>34</sup> van der Waerden (1974); Rogers (1998), p. 16.

<sup>35</sup> Schaefer (2007).

<sup>36</sup> Hunger & Pingree (1989), pp 10-12.

<sup>37</sup> Many of the texts are translated and commented on in Hunger (1992) and Parpola (1993). See also

Once Babylon became independent of Assyrian rule in the 7<sup>th</sup> century BC, the focus of astronomy changed. Unlike the astronomy of the Neo-Assyrian empire, where scholars were employed in many cities across the region, almost all astronomy from the Late Babylonian Period originates from the city of Babylon. The earliest “Diary” type collections of observations are found in this period, a tradition which in all probability grew from a desire to understand celestial motion, and hence predict ominous events, more effectively.

Impressively, the continuous tradition of astronomy continues for more than 800 years, even when the city of Babylon was captured: first by Cyrus the Great in 539BC, when it became part of the Persian Empire; then by Alexander the Great in 330BC, when it became part of the Macedonian Empire. Babylon’s decline continued as Seleucus reportedly deported the city’s population to the new royal city of Seleucia in 274 BC,<sup>38</sup> and around 126 BC Babylonia became conquered into the Parthian empire. Yet the astronomical tradition at Babylon continues in a (presumably) practically deserted city until the last dateable cuneiform texts in the late 1<sup>st</sup> century AD.

Who were the people responsible for compiling astronomical texts for so many centuries? McEwan describes the role of the *ṭupšar Enūma Anu Enlil* (“scribe of *Enūma Anu Enlil*”),<sup>39</sup> an official position at Babylon’s Esagila temple. These scribes were, among other duties, astronomer/astrologers who were hired to “make the observations and give the calculations and measurements”<sup>40</sup>. It is interesting that the job title still referred to *Enūma Anu Enlil* well into the Greek period, when the tradition of interpreting omens had not been in practice for several centuries. It perhaps did not seem as vital to interpret omens concerning the king’s fate once Babylon was under Persian rule and there were no more Mesopotamian kings. Instead, the 5<sup>th</sup> century BC sees the rise of another strand of interpretative astrology in the form of personal horoscopes.

By the Late Babylonian period, Akkadian had fallen out of usage as a spoken language in favour of Aramaic, yet the astronomical texts are still written in the traditional combination of Akkadian syllabic cuneiform and Sumerian logograms. Evidence from the period shows that the knowledge of astronomical observations and calculations was considered highly sensitive and private knowledge,<sup>41</sup> and recording their astronomical information in an obsolete language (in a time when few of the general population could read in any case)<sup>42</sup> would certainly have helped their methods to remain private.

## 1.3.2 Non-Mathematical Astronomy

### 1.3.2.1 Goal-Year Astronomy

As we have already seen, “Goal-Year astronomy” is a general term used to encompass the non-mathematical Babylonian texts which use empirical methods of prediction, relying on the periodic motions of the planets and the Moon to predict future events. As a major question of this thesis is how exactly the Babylonian astronomers predicted planetary events using Goal-Year methods, Chapters 4, 5 and 6 are devoted to various aspects of this

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discussion by Oppenheim (1969).

<sup>38</sup> Recorded in the Babylonian Astronomical Diary *ADART* Vol. I No. -273B.

<sup>39</sup> McEwan (1981), pp. 15-21.

<sup>40</sup> McEwan (1981), p. 20, from a Babylonian temple document dating to around 100 BC. These texts are also discussed in van der Spek (1985), Pearce & Doty (2000), Rochberg (2004).

<sup>41</sup> Rochberg (2004), pp. 212-219 discusses the common warnings on colophons of Babylonian astrological texts that the information they contain is “secret knowledge” that may only be shown to “another one who knows” (p. 212).

<sup>42</sup> Bertman (2003).



topic. Although both lunar and planetary events are predicted using Goal-Year methods, the planetary predictions have received comparatively little attention from researchers in the past. By contrast, both non-mathematical predictions of lunar events (outlined in the following section), mathematical predictions, and horoscopy (both outlined later in this chapter) have been the subject of extensive research and writing by previous scholars, and so the following chapters need not discuss their uses in detail.

### 1.3.2.2 Lunar Astronomy

Being aware of the Moon's appearance and disappearance was very important since, as we have seen, the Babylonian calendar was based on the lunar month. To help keep track of the Moon's phases, the Babylonian astronomers recorded the six time intervals described in Table 1.2, on key dates around the full moon and new moon of each month. These six intervals are now generally known as the Lunar Six.<sup>43</sup>

| Name (cuneiform transliteration) | When during month | Description   |
|----------------------------------|-------------------|---|
| <i>na</i>                        | New moon          | Time interval between sunset and moonset on the first evening the new moon is visible             |
| ŠÚ                               | Full moon         | Time interval between moonset and sunrise the last morning the Moon sets before sunrise           |
| ME                               | Full moon         | Time interval between moonrise and sunset the last evening the Moon rises before sunset           |
| <i>na</i>                        | Full moon         | Time interval between sunrise and moonset the first morning the Moon sets after sunrise           |
| GE <sub>6</sub>                  | Full moon         | Time interval between sunset and moonrise the first evening the Moon rises after sunset           |
| KUR                              | End of the month  | Time interval between moonrise and sunrise the last time that the Moon is visible before new moon |

**Table 1.2: details of the Lunar Six**

Some texts instead include the Lunar Three, which are the dates on which the following three events would be observed: *na* at the beginning of the month, *na* in the middle of the month, and KUR at the end of the month. Modern scholars occasionally refer to the Lunar Four, meaning the four Lunar Six events which occur around full moon. In recent times some significant research has been done on the prediction of Lunar Six values, showing that the Babylonian astronomers were able to predict the timings of Lunar Six events using Goal-Year type periodic relations from the 7<sup>th</sup> century BC.<sup>44</sup>

The other major lunar phenomenon recorded in Babylonian astronomical texts is the eclipse. Eclipse prediction could be considered one of the crowning achievements of Babylonian astronomy; the theory was so well understood that dates of every possible known lunar and solar eclipse could be calculated well in advance – even eclipses which would not have been visible from Babylon.<sup>45</sup> Babylonian eclipse reports vary from very terse (giving just the date and approximate time the eclipse began) to extremely detailed (giving the date, position of the Moon, timing of each phase of the eclipse, measurement of maximal solar/lunar coverage, positions of the planets during the eclipse, and other details<sup>46</sup>).

<sup>43</sup> Following Sachs (1948).

<sup>44</sup> See the work of, for example, Brack-Bernsen (1999a and 1999b), Brack-Bernsen & Hunger (2002), Huber & Steele (2007).

<sup>45</sup> Steele (2000a and b).

<sup>46</sup> Huber & de Meis (2004).

Even though the main focus of this work is on planetary prediction, the connections between planetary and lunar methods of prediction will be considered in subsequent chapters: Chapter 3 includes eclipse predictions in its analysis of the “beginning” and “end” regions of zodiacal signs, and Chapter 6 briefly considers the effect of the Babylonian calendar’s intercalary months on the prediction of Lunar Six events.

### 1.3.3 Mathematical Astronomy

In contrast to the above non-mathematical texts, the mathematical cuneiform texts (mostly published as the *Astronomical Cuneiform Texts* (*ACT*)<sup>47</sup>) are devoted to theoretical schemes of planetary and lunar motion, and calculated predictions of events. The first mathematical astronomical texts date to before the Seleucid Era, and the latest to around SE 350 – a very similar timescale to the dates of extant non-mathematical predictive texts (see Figure 2.1 in the following chapter). *ACT* contains comprehensive descriptions of the texts’ contents and the astronomical theories used to compute the data and so a brief outline of their contents and methods will suffice here.

Neugebauer in *ACT* divides the texts into three categories:

- Ephemerides, which list dates and positions of the Sun, Moon or a planet at the time of key events (such as new moon, or a planet’s Greek-letter phenomena) over a period of, typically, several years. For lunar ephemerides, other calculated data such as latitude and velocity are also included.
- Auxiliary functions, which contain calculations of one of the (fifteen or more) functions needed to construct the lunar ephemerides.
- Procedure texts, which describe the rules and methods behind calculating the ephemerides. The planetary procedure texts are examined further in Chapter 4, which contains an assessment of the planetary periods referred to in these texts along with the various planetary periods mentioned in the few extant examples of other, non-mathematical procedure texts.

One question that is not answered in the Babylonian texts themselves is the nature of the connection between mathematical and non-mathematical astronomy. This raises several potential issues: for example, were the same observations used for both mathematical and non-mathematical predictions of events? As §1.3.5 on “Terminology” will show, lunar and planetary positions in the non-mathematical texts (both observed and predicted) are generally recorded relative to a nearby star, or by a positional statement involving a zodiacal sign. It is rare to find a planet’s position at the time of its first appearance, for example, recorded more precisely than within the 30° region of a zodiacal sign.<sup>48</sup> Yet the mathematical texts calculate positions to an apparently much more precise scale – to within fractions of a degree of a zodiacal sign.

Could the less precise observational records really have been the source of the mathematical ephemerides’ calculated values? Neugebauer believed that the non-

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<sup>47</sup> Neugebauer (1955).

<sup>48</sup> Some texts specify an event with slightly more precision as occurring the “beginning” or “end” of a zodiacal sign – see Chapter 3 for a discussion of the size of these regions. Such regions are, nevertheless, still many times larger than the apparent precision of the mathematical ephemerides.

mathematical texts would have been “useless” for this purpose,<sup>49</sup> although Aaboe<sup>50</sup> and Swerdlow<sup>51</sup> speculate on ways that it could have been done. As with so many aspects of Babylonian astronomy, there is no direct confirmation from the sources and so one cannot be certain.

Secondly, were the same mathematical procedures used to calculate dates of both the mathematical ephemerides and the Goal-Year type predictions? As stated above, Sachs considered the *ACT* ephemerides to be a potential source of the non-mathematical predictions, and it is clear that some connection exists between the mathematical and non-mathematical texts. For example, Huber has shown<sup>52</sup> that dates when a planet was said to reach the zodiacal sign Gemini, Cancer or Aquarius matches dates predicted for a planet to pass by the Normal Star  $\zeta$  Tauri,  $\beta$  Geminorum or  $\delta$  Capricorni respectively.<sup>53</sup> Therefore, the division of the zodiac in the mathematical texts, and the positions of planetary passages from the non-mathematical texts, are at least compatible systems of recording positions.<sup>54</sup> However, in Chapter 2 I show that the planetary ephemerides in *ACT* are extremely unlikely to have been the source of the non-mathematical predictions, so we can be almost certain that the same procedures were *not* used in each case.

Lastly, were the two types of astronomy even carried out by the same people? There is certainly evidence in favour of this situation: firstly, as described above, the mathematical and non-mathematical types of prediction are made using connected, if not identical, methods. Secondly, the existence of temple documents from Babylon, such as the one quoted above in §1.3.1 which concerns the appointment of an astrologer who will “make the observations and give the calculations and measurements”.<sup>55</sup> The wording is not conclusive, but certainly suggests one single group of people carrying out both the mathematical and non-mathematical astronomy.

Yet, one could imagine a situation where two groups of astronomers worked completely separately, one group observing and making predictions based on non-mathematical methods, and the other using mathematical methods. Neugebauer,<sup>56</sup> for example, certainly believed that this was the case.

### 1.3.4 Astrology and horoscopes

As described in §1.3.1, the omen traditions of earlier periods evolved into the personal horoscopes found in the Late Babylonian Period from the 5<sup>th</sup> to the 1<sup>st</sup> centuries BC. There has been extensive analysis of Babylonian horoscopes in recent years, particularly by Rochberg,<sup>57</sup> and so I shall not describe their contents in any detail here. Instead I shall just mention one important link between horoscopy and the other strands of Late Babylonian astronomy: the non-mathematical predictive texts known as Almanacs appear to contain all of the necessary information for the compilation of horoscopes, and it could be speculated that they were created for this purpose.<sup>58</sup> (See Chapter 2 for the contents of the Almanacs.)

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<sup>49</sup> Neugebauer (1989), p. 393.

<sup>50</sup> Aaboe (1980).

<sup>51</sup> Swerdlow (1998).

<sup>52</sup> Huber (1958).

<sup>53</sup> See also Chapter 3 for more discussion of this, and Steele & Gray (2007).

<sup>54</sup> See also Steele (2007a).

<sup>55</sup> McEwan (1981).

<sup>56</sup> Neugebauer (1989).

<sup>57</sup> For example, Rochberg-Halton (1989, 1991), Rochberg (1998, 2004); see also Pingree (1998).

<sup>58</sup> Rochberg (2004), pp. 153-157.

### 1.3.5 Terminology used in Late Babylonian astronomical records

The terminology used to describe astronomical events in the Late Babylonian texts is quite formulaic and terse, and the records have a high logographic content. This means that it can be difficult to determine an exact translation of a record, even while the *concept* which the logogram (or series of logograms) describes can be well understood, due to the periodic and repetitive nature of astronomical records.<sup>59</sup>

This section therefore outlines the important concepts found in the Babylonian astronomical records, which will be referred to in future chapters. The key points which will be described are: i) ii) what reference points the Babylonian astronomers used for recording positions of the planets and Moon; and iii) what units they used to measure distances and times.

#### 1.3.5.1 Planetary names

The planets visible to the naked eye (i.e. Mercury, Venus, Mars, Jupiter and Saturn) are referred to by many different names in the various cuneiform texts.<sup>60</sup> Conveniently, the Late Babylonian astronomical texts with which we are concerned here consistently use only one name for each planet (with a very small number of exceptions). Table 1.3 shows the Akkadian names of the five planets and their possible translations; recall that several alternative translations may be possible due to the many syllabic and logographic interpretations of cuneiform signs. For example, the signs used to denote Mercury could also be read as “the white bull”.

| Planet  | Babylonian name     |                              | Meaning         |
|---------|---------------------|------------------------------|-----------------|
| Mercury | GU <sub>4</sub> .UD | <i>Šiḫtu</i>                 | jumping planet  |
| Venus   | <i>dele-bat</i>     |                              | meaning unknown |
| Mars    | AN                  | to be read <i>šalbatānu?</i> | meaning unknown |
| Jupiter | MÚL.BABBAR          | BABBAR = <i>pešûm</i>        | the white star  |
| Saturn  | GENNA = TUR + DIŠ   | TUR = <i>šeḫru?</i>          | small           |

**Table 1.3: planetary names from the Late Babylonian astronomical texts**

In some of the later Seleucid texts these names may be abbreviated, for example Jupiter may be referred to as BABBAR rather than MÚL.BABBAR.

In the astronomical texts considered in this work, the planets were virtually always considered to follow the conventional sequence of Jupiter, Venus, Mercury, Saturn, Mars. This specific order of the planets is almost invariable in Seleucid Era astronomy and is likely connected with how benefic or malefic each planet’s influence was regarded as being.<sup>61</sup>

#### 1.3.5.2 Sidereal motion

The motion of the planets and the Moon with respect to the stars was recorded by the use of reference stars – a number of bright stars close to the ecliptic, known to us now as Normal Stars,<sup>62</sup> were used for this purpose. A typical report of a Normal Star passage

<sup>59</sup> See for example the translators’ comments throughout the Introduction in Sachs & Hunger (1988), or the decipherment of the text TU11 by Brack-Bernsen & Hunger (2002).

<sup>60</sup> See for example Brown (2000), pp 53-103.

<sup>61</sup> Rochberg-Halton (1988b).

<sup>62</sup> So called following Epping (1889). For a list of the 32 Normal Stars most commonly used in observations see Sachs & Hunger (1988), pp. 17-19.

records the date on which the Moon or planet passed close to a star, and a measurement of how closely it reached the star. Generally these measurements stated that the planet was a certain distance “above” or “below” the star, with (much less commonly) a second measurement of how far the planet was “back to the west” or had “passed to the east” from the star. An alternative, but much less common way of recording the measurements was to record first a distance that the planet was “behind/in front of” the star, combined with a distance that it was “high to the north” or “low to the south”.

There is no Babylonian source to attest exactly what was meant by a planet being “above”, “below”, “in front of” or “behind” a star. Graßhoff believes that these terms correspond to a difference in latitude (above/below) and a difference in longitude (in front of/behind).<sup>63</sup> Jones suggests that the moment when a planet passed a Normal Star was determined by means of an imagined reference line between the star and a reference point at a similar longitude (perhaps another nearby star) – perhaps using the “string” described below.<sup>64</sup> “Above/below” would then be a distance along this line, and (presumably) “in front of/behind” would be a distance in the direction perpendicular to the line.

The distances are almost always given in terms of the Babylonian units of cubits and fingers, where 1 cubit = 24 fingers. It seems from the mathematical texts that a cubit was intended to be an arc of 2°; evidence from the astronomical texts is that it was in practice around 2.3°.<sup>65</sup>

How might the distance measurements have been made? No astronomical tools remain from the period, nor any texts describing exactly how the apparent distances between celestial objects were measured or estimated. Some texts contain somewhat unclear references to “strings”,<sup>66</sup> which allows one to speculate that a string or stick might have provided a visual aid for estimating distances by eye. However, there is no certainty that this was the case.

### 1.3.5.3 Synodic phenomena

The planets’ motion with respect to the Sun was recorded by their synodic phenomena. (As we have already seen, the Moon’s synodic motion was recorded by the dates and times of the Lunar Six.) The synodic planetary events which the Babylonian astronomers watched for and predicted are nowadays known collectively as the Greek-letter phenomena.<sup>67</sup> Table 1.4 summarises which events were recorded for the inferior and superior planets, along with the conventional Greek-letter designations.

| Superior Planets |                         | Inferior Planets |                              |
|------------------|-------------------------|------------------|------------------------------|
| Γ                | First visibility        | Γ                | First visibility in the east |
| Φ                | First stationary point  | Σ                | Last visibility in the east  |
| Θ                | Acronychal rising       | Ξ                | First visibility in the west |
| Ψ                | Second stationary point | Ω                | Last visibility in the west  |
| Ω                | Last visibility         |                  |                              |

**Table 1.4: details of the Greek-letter phenomena**

<sup>63</sup> Graßhoff (1999).

<sup>64</sup> Jones (2004).

<sup>65</sup> Steele (2003).

<sup>66</sup> For example, Pingree & Walker (1988); Brack-Bernsen & Hunger (2002), p.19.

<sup>67</sup> So called following Sachs (1948) and Neugebauer (1954), who assigned each phenomenon a particular Greek letter in order to be able to refer to them more concisely.

Note that “acronychal rising” has often been assumed to mean the planet’s opposition with the Sun. It has now been shown that the moment of acronychal rising was actually more likely to be the point at which the planet rose at sunset – close to the moment of opposition, but not exactly the same.<sup>68</sup>

A typical report of a planet’s Greek-letter phenomenon includes the date on which the phenomenon was observed (or expected) and, sometimes, details of the planet’s position at the time of the event. The level of detail recorded varies depending on the type of phenomenon. Generally a record of an acronychal rising will give no information at all on the planets’ position. Records of first or last visibilities usually state in which zodiacal sign the planet was on that date (i.e. in which region of the ecliptic - see the following section).<sup>69</sup> Observations of stationary points tend to record the planets’ position with reference to either its zodiacal sign or its proximity to a Normal Star; Chapter 3 examines some of the differences from this format found in *predictions* of stationary points.

#### **1.3.5.4 Zodiacal signs**

The concept of the zodiac, first seen in texts from around the 5<sup>th</sup> century BC, was an immensely important development in Late Babylonian astronomy. The concept of dividing the ecliptic into 360 equal regions (i.e. 360°) and further into 12 signs each 30° long, greatly improved the ease of calculating celestial positions.<sup>70</sup> Previously, planetary positions at the time of, say, Greek-letter phenomena, would be recorded relative to nearby constellations, which were irregularly-sized and did not cover the entire sky. Compared with this, the concept of a theoretical division of the ecliptic, which did not necessarily relate to anything visible on the sky<sup>71</sup> but provided a sequence of regularly-spaced divisions with no gaps, makes mathematical astronomy much easier to carry out.

Table 1.5 lists the zodiacal signs used by the Babylonian astronomers, showing a transliteration of the Akkadian name and its translation, along with the modern Western name of the corresponding zodiacal sign and its longitude. (Note that the correspondence between regions of the zodiac and specific longitude ranges has altered since Babylonian times due to the precession of the equinoxes, which must be taken into account when calculating longitudes of synodic events.<sup>72</sup>) It is easy to see that many of our modern names for the zodiacal regions have their origin in the Babylonian zodiac. Chapter 3 examines in more detail when and how the Babylonian astronomers used the zodiac.

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<sup>68</sup> Swerdlow (1999), Hollywood & Steele (2004).

<sup>69</sup> Alternatively, an occasional expected appearance or disappearance of Mercury is described as “omitted”, rather than any information on its position being recorded. This means that it was not visible from Babylon for the whole of its eastern or western phase; Chapter 7 examines in some detail why and when this was the case.

<sup>70</sup> Brack-Bernsen & Hunger (1999), Steele & Gray (2007).

<sup>71</sup> As described in the section on mathematical astronomy, Huber (1958) shows how the boundaries of some zodiacal signs were designated by particular Normal Stars. However, not all of the zodiacal boundaries have bright objects located conveniently nearby.

<sup>72</sup> Huber (1958), Steele & Gray (2007).

| Babylonian name    |             | Modern name | Beginning of zodiacal sign – longitude |
|--------------------|-------------|-------------|--|
| HUN                | Hired Man   | Aries       | 0°                                     |
| MÚL                | Bull        | Taurus      | 30°                                    |
| MAŠ                | Twins       | Gemini      | 60°                                    |
| KUŠÚ               | Crab        | Cancer      | 90°                                    |
| A                  | Lion        | Leo         | 120°                                   |
| ABSIN <sub>x</sub> | Barleystalk | Virgo       | 150°                                   |
| RÍN                | Balance     | Libra       | 180°                                   |
| GÍR.TAB            | Scorpion    | Scorpio     | 210°                                   |
| PA                 | Pabilsag    | Sagittarius | 240°                                   |
| MÁŠ                | Goat-Fish   | Capricorn   | 270°                                   |
| GU                 | Great One   | Aquarius    | 300°                                   |
| zib. <sup>ME</sup> | Tails       | Pisces      | 330°                                   |

**Table 1.5: the names and longitude ranges of the zodiacal signs used in Babylonian astronomy**

### 1.3.5.5 Time measurements

Now that we have examined measurements of position and distance, let us move onto measurements of time. For non-mathematical planetary events, this is very simple: Normal Star passage records state whether the planet was visible in the early or late part of the night, but (reasonably) do not make any attempt to observe the exact time of a passage. The planets, even Mercury, do not move fast enough that it would make any sense to record the time of a passage with any more accuracy than to within a few hours. For lunar passages by Normal Stars, a similar terminology is found.

The regular Lunar Six measurements record how long the Moon is visible for around sunrise or sunset, and occasionally a similar measurement for a planets' length of visibility is noted around the time of an appearance or disappearance. (This is discussed further in the following chapter.) The time is always recorded using the Babylonian unit of time “*u*”; *u* is commonly rendered as “degree” in translation, because there were 360 *u* in a day. From remarks in Babylonian texts, it seems that these times were probably measured using a waterclock.<sup>73</sup>

Another way of measuring time is found in eclipse observations. The time of a *predicted* eclipse is always given in terms of degrees before/after sunrise or sunset. The same terminology can be found in observational records of eclipses; alternatively, in later observational texts the time an eclipse began was often recorded relative to the culmination of a particular star or group of stars.<sup>74</sup>

Finally, for records of all other periodic events which are found in the observational texts (such as equinoxes, solstices or the appearance of Sirius<sup>75</sup>) only the date of the event would be recorded.

Another method of recording the passage of time is found in the mathematical astronomical texts: rather than having the confusion of whether individual months have 29 or 30 days when calculating dates, a division of time known as a “tithi” is regularly used for

<sup>73</sup> Neugebauer (1947), Stephenson (1974), Hunger & Pingree (1989).

<sup>74</sup> A list of the stars used for this purpose, known as “ziqupu stars”, is found in MÚL.APIN (Hunger & Pingree, 1989).

<sup>75</sup> For these particular events the *predicted* date was almost invariably recorded, as shown in the above section on “Calendrical Systems”; see also Chapter 2. For details of records involving the rising and setting of stars other than Sirius, see Chapter 3.

calculations instead.<sup>76</sup> A tithi is defined by dividing the length of the mean synodic month into 30 parts, i.e.  $1 \text{ tithi} = \sim 29.531 \text{ days} \div 30 = \sim 0.984 \text{ days}$ . Tithi are very useful for simplifying mathematical calculations of dates, though they are not found in the non-mathematical texts.

### ***1.4 Modern calculations of Babylonian astronomical events***

As later chapters will show, modern calculations of astronomical ephemerides can be an extremely useful tool with which to compare ancient records. During the course of this study, several computer programs which calculate various astronomical events have been used for this purpose. These programs, along with the assumptions used in the calculations of each one, are outlined below. A computer program can calculate centuries of astronomical events extremely quickly, with no loss of data due to erosion of texts or due to bad weather having prevented observation, and hence can provide large datasets which can be used to aid our understanding of ancient astronomical methods. However, one must exercise caution and question what assumptions have been made during the calculation of these ephemerides.

For example, calculating dates of sidereal events such as Normal Star passages is reasonably straightforward – in effect, one only needs to calculate the planet’s daily longitude and latitude, which can then be compared with the known longitudes and latitudes of the Normal Stars at that time. Conversely, calculating the date on which a planet or star is visible for the first or last time depends on what values have been assumed for several variables, such as the quality of atmospheric viewing conditions at the horizon, or the distance below the horizon the Sun must be for a particular planet to be visible. Obviously, it is impossible to find a method of calculation which would perfectly replicate the recorded Babylonian dates of planetary phenomena, because the day-to-day observing conditions could never be reproduced exactly. Therefore, one must not use these computer programs expecting exact Babylonian dates of phenomena but rather *approximate* dates on which the phenomena could have been viewed in Babylon, perhaps assuming slightly better viewing conditions than were available at the time.

In general, one needs to be able to account for:

- i) The methods used to assess a star or planet’s visibility (if a program calculates dates of phenomena), particularly around its appearance or disappearance. The dates do not need to match the Babylonian records exactly, but one needs to show that they consistently approximate the Babylonian records of dates;
- ii) Whether calculated longitudes are tropical, or whether they have been altered to account for the precession of the equinoxes;
- iii) What values have been used when accounting for the long-term changes in the Earth’s rotation speed. A recent estimation of the parameters suggests that during the centuries spanned by the Late Babylonian Period,  $\Delta T$  varies between approximately 10,000 – 15,000s  $\approx$  3 to 4 hours.<sup>77</sup> As we have already seen, the planetary events which are investigated in this study are not generally recorded with a precise time, only to within a day. In practice, this means that it will rarely make a difference to the computed dates of Babylonian planetary events whether they are calculated using Universal Time (UT) or Terrestrial Time (TT). However, it will still be useful, if possible, to determine what values the programmers have used.

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<sup>76</sup> The name “tithi” is the word used for the same concept in Indian astronomy.

<sup>77</sup> Stephenson (1997).



### 1.4.1 The “Horizons” ephemeris

This tool from Caltech’s Jet Propulsions Laboratory provides highly accurate ephemerides for solar system objects, using values for the orbital parameters which are as precise as statistically possible.<sup>78</sup> In terms of the present study, this means it provides a useful source of planetary tropical longitudes and latitudes relative to an observer in Babylon.

When calculating dates and times, the formula this tool uses for  $\Delta T$  is:

$$\Delta T = 31 T^2$$

where  $T$  is the number of centuries since 1820. This suggests that dates within the Late Babylonian Period will have a value for  $\Delta T$  of around 10,000 to 19,000s – a fine approximation.

### 1.4.2 The “Bretagnon” ephemeris

A computer program has been developed by F. R. Stephenson and K. K. C. Yau which calculates positions of the planets and the sun relative to an observer in Babylon, based upon the Bretagnon ephemeris.<sup>79</sup> Bretagnon et al thoroughly discuss the accuracy of the solar and planetary tables in their paper, and the authors also explain why they have *not* taken  $\Delta T$  into account at all, instead choosing to express their tables in terms of Ephemeris Time.<sup>80</sup>

In practice this means that the “Bretagnon” computer program calculates tropical longitudes and latitudes which agree extremely well with those calculated by the “Horizons” ephemeris, but offset by some 3 to 4 hours due to the application of  $\Delta T$ .

### 1.4.3 N. A. Roughton’s planetary tables

Roughton has made available his planetary tables, which show calculated dates of ephemerides associated with Normal Star passages and Greek-letter phenomena for the planets across a period of several hundred years between 602 BC and 76 AD. The criteria employed to determine event dates are described in his explanatory paper, and some of the calculated results are compared with records of Babylonian dates.<sup>81</sup>

In general, the dates in Roughton’s tables are a very good approximation of Babylonian dates of events. However, it must be noted that the tables show a particular lack of agreement with the Babylonian records of the date on which a planet becomes stationary. Roughton explains that the calculated dates of stations are those where the planet reaches a maximum or minimum in longitude to 3 decimal places, a level of precision which is clearly impossible to determine by eye. This difficulty with observing a planet’s true station will be discussed further in Chapter 4.

It must also be noted that Roughton’s tables differ from the Babylonian texts in that they omit entirely the eastern or western phases where Mercury never meets the criteria for visibility. As we have seen, in the Babylonian texts dates of these missing appearances and disappearances are noted with the terminology “omitted”; this will be discussed further in

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<sup>78</sup> The “Horizons” tool, and its full documentation, can be found online at <http://ssd.jpl.nasa.gov/horizons.cgi>.

<sup>79</sup> Bretagnon et al (1985), with thanks to F. R. Stephenson for making his FORTRAN program available.

<sup>80</sup> Bretagnon et al (1985), pp. 42-43.

<sup>81</sup> Roughton (2002), with thanks to N. A. Roughton for making his databases of planetary events available.

Roughton's paper makes no mention of  $\Delta T$ . The calculated dates are recorded in the form of a Julian day number, suggesting that no TT-UT correction has been applied.

#### 1.4.4 The “Alcyone” ephemeris

The “Planetary, Lunar and Stellar Visibility” function of this ephemeris can be used to calculate the rising and setting times of the sun, Moon, a planet, or a star from any location on earth.<sup>82</sup> For the present study, this means that the software can usefully be used to determine dates on which a star or planet might have been visible from Babylon.

A brief investigation demonstrates that the criteria assumed by the software for an object's visibility from Babylon do not match exactly with dates in the Babylonian texts, as expected. For example, around 100 BC the ideal scheme used during the Seleucid Era to calculate Sirius' yearly phenomena corresponded to the following dates in the Julian calendar:<sup>83</sup>

Last appearance - ~14<sup>th</sup> May

First appearance - ~18<sup>th</sup> July

Acronychal rising - ~1<sup>st</sup> January.

The Alcyone software returns these dates for the same phenomena:

Last appearance - ~11<sup>th</sup> May

First appearance - ~20<sup>th</sup> July

Acronychal rising - ~27<sup>th</sup> December.

In other words, the software can provide a good general tool for understanding when a planet or star may be visible from Babylon or not, but it should not be used for determining exact dates of phenomena.

The documentation for the Alcyone software compares eight different models for  $\Delta T$ . Unfortunately the documentation does not directly state (at the time of writing) which of these models they follow in their ephemerides calculations.

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<sup>82</sup> The “Alcyone” software, and its full documentation, can be found online at <http://alcyone.de/>.

<sup>83</sup> The dates of the scheme are summarised in Hunger & Pingree (1999), p. 153.

## Chapter 2

### The non-mathematical astronomical texts

Let us now move on to examining in detail the various text types used in Goal-Year astronomy. Over 60 years ago, Abraham Sachs classified the non-mathematical astronomical texts into four categories: the Astronomical Diaries, Goal-Year Texts, Normal Star Almanacs and the Almanacs.<sup>84</sup> Despite working from only a handful of texts, his classifications have proved remarkably robust and are still applicable today to the many non-mathematical tablets which have been identified since then. To these four categories we add a fifth, more general category to cover other lunar and planetary texts.

This chapter will describe the contents of the various types of texts, and examine how the records in them are connected. As stated in the previous chapter, when making reference to a particular text which has been translated by Sachs & Hunger<sup>85</sup> I refer to as *ADART* Vol. m No. n. This chapter also deals with texts which have not yet been published in translation, and when this is the case I will refer to a text as *LBAT m*<sup>86</sup> or its museum number as appropriate.<sup>87</sup>

#### 2.1 The Astronomical Diaries

The basic observational texts of the period are known as Astronomical Diaries, which contain nightly records of a varied collection of astronomical events. The earliest extant Diary covers the year -651 and the latest one covers the year -60, so the Diaries were evidently produced across the entire Late Babylonian Period (in accordance with Ptolemy's statement that he had complete records dating back to the reign of Nabonassar).<sup>88</sup> However, unlike the records available to Ptolemy, our archive of Diaries is much smaller; particularly for the pre-Seleucid centuries. We have only one extant Diary from each of the 7<sup>th</sup> and 6<sup>th</sup> centuries BC, and only two from the 5<sup>th</sup> century BC. Inevitably some tablets have gone missing or sustained damage over the intervening 2000 years; Figure 2.1 later in this chapter shows for which years Diaries have survived to the modern day.

A typical Astronomical Diary covers 6 or 7 months<sup>89</sup> and records, on a nightly basis, astronomical events including:

- Passages of the Moon and the planets by Normal Stars,
- The planets' Greek-letter phenomena and the Lunar Six,
- Observed eclipses, or dates of eclipse possibilities,
- Dates of solstices, equinoxes, and the star Sirius' Greek-letter phenomena,

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<sup>84</sup> The text types are classified according to Sachs (1948).

<sup>85</sup> All known and dated Diaries have been published in Sachs & Hunger (1988, 1989, 1996), except for a very few which have been dated since; translations of all known Goal-Year Texts have been published in Hunger (2006); translations of all known non-mathematical lunar and planetary texts have been published in Hunger (2001), except for some which were instead published in Hunger (2006): *ADART* Vol. VI Nos. 19, 24.

<sup>86</sup> Sachs (1955), *Late Babylonian Astronomical and Related Texts* (hereon abbreviated to *LBAT*). In keeping with Sach's terminology, an *LBAT* number with no asterisks means that a copy of the text was included in *LBAT*; an *LBAT* number with one asterisk means that the text was not copied into *LBAT* and that it had not been published elsewhere (as of 1955); an *LBAT* number with two asterisks means that a copy or a translation of the text had already been published before *LBAT*.

<sup>87</sup> Many copies of other Babylonian astronomical texts can be found in Epping's *Astronomische aus Babylon* (1889), and parts I and II of Kugler's *Sternkunde und Sterndienst in Babel* (1907 and 1924); (hereafter abbreviated to *AAB*, *SSB I* and *SSB II* respectively), also Kugler & Schaumberger (1935).

<sup>88</sup> As discussed in the previous chapter, and in Sachs (1974).

<sup>89</sup> Although shorter Diaries covering fewer months, or only a few days, are not uncommon – see Hunger & Pingree (1999), pp 142-4.

Other, less common, astronomical events such as comets,  
The weather, particularly when it was bad enough to prevent observing, or in the  
case of an ominous event such as a rainbow.

At the beginning of each month is a statement of whether the previous month had 29 or 30 days, and at the end of each month is a summary of the planets' positions during the month<sup>90</sup> and a section summarising non-astronomical events. In later Diaries (infrequently from -453 onwards, and regularly from -266) the planetary summary would also contain the dates of planets' first and last appearances (and, very occasionally, other Greek-letter phenomena). From -212 onwards the summaries also generally contained the dates on which a planet moved to the next zodiacal sign – see Chapter 3 for more discussion of this development.

In the non-astronomical section would typically be found prices of staple goods in Babylon's market during the month,<sup>91</sup> measurements of the river level and how it changed during the month; and a report of news which had reached the Diary compilers' attention, either events occurring in the city of Babylon or news from elsewhere. Earlier Diaries also occasionally record events which could be seen as ominous such as the hatching of a three-footed bird.<sup>92</sup>

### 2.1.1 The effect of bad weather on the Astronomical Diaries' records

It is important to note that although the Diaries are primarily observational texts, from the very earliest texts they also contain calculated dates and measurements. In particular, Lunar Six measurements and dates of events are found to be estimated at times when the weather is too bad for observation; and dates of solstices, equinoxes and Sirius phenomena were nearly always calculated according to a 19-year scheme from the 4<sup>th</sup> century BC onwards.<sup>93</sup> Similarly, the dates of possible eclipses were calculated according to a scheme throughout the entire period and, while some Diaries contain extremely detailed reports of eclipse observations, dates of eclipses which would not have been visible from Babylon were, of course, always calculations rather than observations.<sup>94</sup>

Compensating for observations which were missed due to bad weather is a feature of all of the Astronomical Diaries. That an event was estimated or calculated rather than observed is noted by the logograms NU PAP, translated by Sachs & Hunger as "I did not watch", and often accompanied by a remark on the weather. For example:

GU<sub>4</sub>-UD *ina* NIM *ár* <sup>mul</sup>xKUN<sup>me</sup> ŠÚ(!) ù SAG-UŠ *ár* <sup>mul</sup>xKUN<sup>me</sup> ŠÚ  
U<sub>4</sub><sup>me</sup> ŠÚ<sup>me</sup> NU PAP  
"Mercury's last appearance in the east behind Pisces, and Saturn's last  
appearance behind Pisces; I did not watch because the days were  
overcast."  
(*ADART* Vol. I No. -651, col. i 7-8)

<sup>90</sup> This is standard by the date of the 3<sup>rd</sup> oldest Diary, *ADART* Vol. I No. -463, onwards. The 2<sup>nd</sup> oldest Diary, *ADART* Vol. I No. -567, appears to have a planetary positions summary at the *beginning* of the month. These early texts summarise planetary positions with respect to nearby constellations; later texts instead summarise planetary positions within zodiacal signs. (Again, with such sparse records for the early part of the period it is extremely difficult to narrow down the dates of astronomical developments.)

<sup>91</sup> The market prices and fluctuations have been analysed by Slotsky (1997).

<sup>92</sup> *ADART* Vol. I No. -418. Ominous births and weather events are significantly more common in the earlier Diaries, becoming less common as the importance of *Enūma Anu Enlil* omen interpretation waned.

<sup>93</sup> Neugebauer (1948), Sachs (1952b).

<sup>94</sup> Steele (2000a).

| Text no. |                     | Year<br>(SE) |     | Date            |   |
|----------|---------------------|--------------|-----|-----------------|---|
| Diary    | -182 A              | Obv. 13      | 129 | 23              | Mercury's last appearance in the west in Gemini;<br>clouds; I did not watch             |
| Alm      | LBAT 1123           | Obv. 5       | 129 | 21              | Mercury's last appearance in the west in Gemini   |
| Diary    | -178 A              | Obv. 9       | 133 | [10]            | Mercury's last appearance in the [east] in Leo;<br>I did not watch; the north wind blew |
| NSA      | MLC 1885            | Obv. 9       | 133 | 10              | Mercury's [last] appearance in the east in Leo  |
| Diary    | -132 D <sub>1</sub> | Rev. 21      | 179 | 14              | Mars' last appearance in Aries;<br>clouds; I did not watch                              |
| Alm      | LBAT 1135           | Rev. 5       | 179 | 14              | Mars' last appearance in Aries  |
| Diary    | -122 A              | Obv. 10      | 189 | Around the 4    | Mercury's last appearance in the west in Taurus;<br>clouds; I did not watch             |
| NSA      | LBAT **1055         | Obv. 8       | 189 | 4               | Mercury's last appearance in the west in Taurus   |
| Diary    | -77 B               | Obv. 14      | 234 | Around the 8    | Mars' acronychal rising;<br>I did not watch   |
| Alm      | LBAT 1164-5         | Rev. 1       | 234 | 8               | Mars' acronychal rising   |
| Diary    | -77 B               | Rev. 10      | 234 | Around the 28   | Mercury's last appearance in the east in Aquarius;<br>clouds; I did not watch           |
| NSA      | BM 32247            | Rev. 15      | 234 | 28              | Mercury's last appearance in the east in Aquarius                                       |
| GYT      | 37                  | Obv. 7       | 96  | 13              | Mercury's last appearance in the west in Gemini;<br>I did not watch                     |
| NSA      | LBAT **1007         | Obv. 6       | 96  | 13              | Mercury's last appearance in the west in Gemini   |
| GYT      | 37                  | Obv. 11      | 96  | 21 <sup>2</sup> | Mercury's first appearance in the east in Capricorn;<br>I did not watch                 |
| NSA      | LBAT 1008           | Rev. 14-15   | 96  | 21              | Mercury's first appearance in the east in Capricorn                                     |
| GYT      | 92                  | Obv. 13      | 201 | Around the 11   | Mercury's last appearance in the west in Gemini;<br>I did not watch                     |
| NSA      | LBAT **1059         | Obv. 10      | 201 | 11              | Mercury's last appearance in the west in Gemini   |

**Table 2.1: a comparison of dates of events in the Astronomical Diaries, described as having not been observed, with the predicted date of the same event in the Almanac or Normal Star Almanac for the same year. In 8 out of the 9 cases the dates are the same, suggesting that when the weather was bad enough to prevent observing, event dates in the Astronomical Diaries were supplied from the predictive texts.**

In many cases where the weather prevented observation of a planetary event an estimate of the event's date is made, with the record including the Akkadian word *in*, translated by Sachs & Hunger as “around the”, date. However, there are also several examples of records where the NU PAP terminology is used and yet an exact date is given for the event. This suggests that, unlike the “around the” terminology which could just refer to a rough estimate, in these cases the exact date was calculated in some way. How might this have been done?

Unfortunately, the small amount of extant data, particularly for the early part of the period, does not allow us to be sure how dates were estimated or calculated. One possibility is via interpolation, for example estimating the date of a planetary phenomenon based on the date of the immediately previous or following phenomenon. This method would have strong links with the *ACT* methods for calculating dates of successive phenomena, particularly the dates of Mercury's “omitted” phases – see Chapter 7 for discussion of these issues.

In the later part of the period, a simpler method to determine dates of events missed due to bad weather would have been to copy event dates from the non-mathematical predictions in the Normal Star Almanacs and the Almanacs (described in the following sections). If this were the case then one would find that the recorded date of a phenomenon described as “NU PAP” in a Diary (or Diary excerpt text such as a Goal-Year Text – described in §2.2) would agree with the *predicted* date of the same phenomenon in an Almanac or Normal Star Almanac for the same year. Table 2.1 summarises the pairs of records which fulfil these criteria.

The lack of overlap between the extant various types of text (see Figure 2.1 later in the chapter) means that there are unfortunately few remaining records which can be compared in this way. Only nine examples remain where a Diary describes a phenomenon as unobserved and a predictive text still exists for the same year to provide the date of the same event. However, of these nine examples, eight of the record pairs available for comparison agree in date. Therefore, it is possible to conclude that during times of bad weather which prevented observing, dates of events were likely to have been filled in from the predictive texts.

### 2.1.2 The use of “ideal” phenomenon dates in the Astronomical Diaries

A particular terminology is frequently found in Diaries where the first sighting of a planet was judged to be some days later than its *true* first appearance should have been, due to, say, bad weather. A typical example is given here:

18 *dele-bat ina* NIM *ina* TIL MÚL-MÚL IGI KUR NIM-*a* 9,30 *na-su in* 16  
IGI

“The 18<sup>th</sup>, Venus' first appearance in the east in the end of Taurus; it was bright (and) high, rising of Venus to sunrise: 9°30; (ideal) first appearance on the 16<sup>th</sup>”

(*ADART* Vol. II No. -167A, Obv. 8 to Rev. 2)

A concept is introduced here which was translated by Sachs & Hunger as the “ideal” date of an observation. In essence, this is simply an estimated correction to the date of events. We can interpret the above example as the Babylonian astronomers stating that they first viewed Venus on the 18<sup>th</sup> of the month, but that due to its distance from the Sun on that day (i.e. the length of time it took to rise after sunrise), it should actually have been visible two days

earlier.

The equivalent case is also found for last appearances: a date on which the planet was “last seen”, and then an expected “last appearance” estimated for some days later. Presumably the measured time difference allowed the astronomers to estimate the required number of days’ correction, but we do not yet understand exactly how this was achieved.<sup>95</sup>

The ideal dates of events can often be found in the Diaries’ end of month planetary summaries. Planetary summaries may include the observed or the ideal phenomenon date, or another date entirely; it may record only the date or additionally use the “around the” date terminology as described in §2.1.1. To help understand how these various practices changed over time, Appendix A contains details of the Astronomical Diaries’ planetary summary contents, to show how often the planetary summaries used the observed or ideal date of an event. The Appendix only includes years for which extant end-of-month summaries, including at least one date of a planetary event, remain. Few useful conclusions can be drawn from Diaries which do *not* fulfil these criteria, which is why they do not appear in the Appendix. That is, it can be difficult to distinguish whether a planetary summary that appears not to contain dates of planetary events does so because it was the scribe’s practice not to summarise the dates, or because no planetary events worth summarising occurred during that month, or because the summary may have contained dates at one point but is now broken.

Despite these concerns, it is clear that very few of the pre-Seleucid Diaries include event dates in the planetary summaries, compared with later Diaries. The inclusion of dates seems to have become a standard practice during the early Seleucid Era. The earlier summaries also include only the observed date of an event, even if an ideal date was also recorded; the earliest Diary in which a planetary summary definitely recorded an ideal event date (as far as can be judged from the unbroken records) is from -284. From -260 onwards the planetary summaries always include the ideal date if one was recorded, except for an anomalous summary in -197 which records neither the observed nor the ideal date but a different date again.

The later planetary summaries also tend to record dates of events as “around the” date, even when an exact date is recorded in a text. This terminology is not found in extant planetary summaries from before -286. Another interesting trend is noticeable between -193 and -183: planetary summaries from this date can repeat the entire event record from the text, including both the observed and ideal dates, timing measurements between the planet’s visibility and sunrise/sunset, etc. Only in this 10-year period are such detailed reports of events found within the planetary summaries.

Table 2.2 summarises the records in the Appendix, by showing how many months record the ideal date or the observed date of an event. There are four main categories:

- i. Text does not include ideal date – summary records observed date
- ii. Text includes ideal date – summary records observed date
- iii. Text includes ideal date – summary records ideal date
- iv. Text is broken – summary records a date which could be observed or ideal

In addition, a few anomalous records do not fit into any of these categories, as described above. Category iv, despite being the most unhelpful, is also unfortunately the most common. It is necessary to stress that one must be wary of drawing absolute conclusions

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<sup>95</sup> See the work of, for example, Hunger (1988), Swerdlow (1998), Hollywood (2002).

from a dataset which includes only 182 records spanning 400 years. This is particularly relevant when nearly half the planetary summaries which include the date of an event are from a broken text, such that we cannot be clear whether the planetary summary is repeating the ideal or observed date.

| Contents of planetary summary  | Number of records | Percentage of records |
|--|-------------------|-----------------------|
| Text does not include ideal date - summary includes observed event date or "around the" observed event date only               | 62                | 34.07%                |
| Text includes observed and ideal event date - summary includes observed event date only  | 4                 | 2.20%                 |
| Text includes observed and ideal event date - summary includes ideal date or "around the" ideal date only                      | 32                | 17.58%                |
| Summary includes a date or "around" a date but textual record is broken, so the summary date could be either observed or ideal | 78                | 42.86%                |
| Summary includes both observed and ideal event dates   | 5                 | 2.75%                 |
| Summary includes a date which is neither observed nor ideal  | 1                 | 0.55%                 |
| Total  | 182               |                       |

**Table 2.2: dates of Greek-letter phenomena in the Diaries' planetary summaries, showing whether they include the observed date or the ideal date from the text. Apart from a few anomalous cases, and the unfortunately many records where the text of the observation is broken, the clear trend is for the planetary summary to include the ideal date when one was recorded, and the observational date when an ideal date was not recorded.**

Of the other categories, i and iii are common and ii is particularly uncommon (and only found in the earlier texts). Three conclusions can be drawn from this. Firstly, more often than not, records of phenomena do *not* include an ideal date. In such cases the planetary summary will obviously copy the observed date of the event. Secondly, if a record of a phenomenon includes an ideal date, the planetary summary will almost invariably copy the ideal date in preference to the observed date. Thirdly, the planetary summaries give no indication of whether the copied dates are ideal or observed. These can only be distinguished by referring to the monthly text of a Diary – which is frequently broken, as we have seen.

Based on this it is important to bear in mind that texts which are made up of Diary excerpts (i.e. texts in *ADART* Vols. V and VI – see §2.2 and §2.5) can include dates which are either the actual date of an observation, or the expected ideal date – and it is not always clear which is true of any particular record. Huber's analysis of the same problem also reached the conclusion that the Diaries' planetary summaries tend to contain what he calls the "inner" observations, i.e. the ideal date of an event.<sup>96</sup>

### 2.1.3 Duplicate records in the Astronomical Diaries

On occasion, more than one Astronomical Diary exists for the same Babylonian year. This is quite reasonable – as we have established, Diaries typically cover half a year so two are needed for a full year. However, it is interesting to examine the cases where two or more Diaries cover an overlapping time period<sup>97</sup> - in some cases, up to 4 texts exist for the same

<sup>96</sup> Huber (1982), p. 12. See also Huber (1977).

<sup>97</sup> Hunger & Pingree (1999), p. 143 list all years for which overlapping Diaries exist.



month.<sup>98</sup> Often such texts are exact duplicates, but there are several cases where details differ between the two texts. Tables 2.3, 2.4 and 2.5 summarise the ways in which parallel records can differ: Table 2.3 contains all the records which differ on the measured distance of a Normal Star passage, Table 2.4 contains all the records which differ on the timing of a Lunar Six measurement, and Table 2.5 contains all the records which differ on the date of a planetary event.

The record comparisons all come from different Diaries for the same year or from the Lunar texts collected in *ADART Vol. V* (described in §2.5), which contain excerpts from the Diaries. Some of the differences in these tables are undoubtedly copying errors rather than disagreements; the cuneiform system of numbers means that confusing 1 and 4, or 4 and 7, can be quite easy to do. Nevertheless, the tables demonstrate that there could be substantial divergence in records of the same astronomical event, and this is strong evidence that multiple people were involved in observing and compiling the Diaries. Table 2.3 shows that estimations of a planet-star distance regularly differed by as much as half a cubit. On the other hand, Table 2.5 shows that discrepancies in the recorded dates of events were extremely uncommon. Only seven date differences were found in parallel Diaries, of which 4 come from the same pair of texts. Disagreements regarding the date of a planetary event should therefore be regarded as an extremely unusual event.

|         | Text No.                      | Measurement 1                               | Text No.                    | Measurement 2           |
|---------|-------------------------------|---|-----------------------------|-------------------------|
| Moon    | -191A, 27'                    | 1 ½ cubits                                  | -191B, Obv. 2               | 2 ½ cubits              |
|         | -178C, Obv.' 7                | 4 cubits                                    | -178D, Obv.' 8              | 5 cubits                |
|         | -132B Obv. 31                 | 2 cubits                                    | -132C Obv. 4                | 3 ½ cubits              |
|         | -132B Rev. 6                  | 1 ½ cubits                                  | -132C Obv. 12               | 2 cubits                |
|         | -132B Rev. 6                  | 1 ½ cubits                                  | -132C Obv. 13               | 2 cubits                |
|         | -132B Rev. 9                  | 2 cubits 6 fingers                          | -132C Obv. 16               | 1 ½ cubits              |
|         | -119B <sub>1</sub> , Rev.' 2' | 2 2/3 cubits                                | -119C, 'Obv. 20'            | 2 5/6 cubits            |
|         | -119B <sub>1</sub> , Rev.' 3' | 2 <sup>3</sup> cubits                       | -119C, 'Obv. 21'            | 1 ½ cubits              |
|         | -105A, 'Obv.' 21'             | 3 cubits                                    | -105B, 'Obv.' 20'           | 2 ½ cubits              |
|         | -105A, 'Obv.' 25'             | ½ cubit                                     | -105B, 'Obv.' 23'           | 2/3 cubit               |
|         | -105A, 'Obv.' 28'             | 3 ½ cubits                                  | -105B, 'Obv.' 25'           | 4 cubits                |
|         | -105A, 'Obv.' 33'             | 1 cubit                                     | -105B, 'Obv.' 31'           | 1 cubit 6 fingers       |
|         | -105A, 'Obv.' 41'             | 2 ½ cubits                                  | -105B, 'Obv.' 38'           | 2 cubits                |
|         |                               |   | Vol V No. 58, 'Rev. IV 21'- |                         |
| Mercury | -384, 'Obv.' 10               | 2 cubits 4 fingers                          | 22'                         | 2 cubits 8 fingers      |
|         | -255A, Obv.' 17               | 1 ½ <sup>sic</sup> cubits                   | Vol V No. 73, Rev. III 17   | 4 ½ cubits              |
|         | -209C, 'Obv. 10'              | 1 <sup>3</sup> cubit 8 <sup>3</sup> fingers | -209D, 'Obv. 10'            | 1 ½ <sup>3</sup> cubits |
| Venus   | -209C, 'Obv. 3'               | 1 cubit                                     | -209D, 'Obv. 5'             | 1 cubit 4 fingers       |
|         | -132B Rev. 3                  | ½ cubit                                     | -132C Obv 10                | 2/3 cubit               |
|         | -132B Rev. 13                 | 1 ½ cubits                                  | -132C Obv 21                | 1 cubit                 |
|         | -105A, 'Obv.' 26'             | 3 cubits                                    | -105B, 'Obv.' 24'           | 3 ½ cubits              |
| Jupiter | -168B, 'Obv.' 9'              | 8 fingers                                   | -168D, LE 2                 | 6 fingers               |

**Table 2.3: details of records where Diary observations report different distance measurements for the same event, taken from either the Astronomical Diary translations in ADART Vols I-III, or the Diary excerpts in ADART Vol. V.**

<sup>98</sup> *ADART* Vol. II No. -168A-D.

| Text No.        |              | Month | Phenomenon      | Measurement   |
|-----------------|--------------|-------|-----------------|---------------|
| Diary No. -321  | 'Rev. 19'    | VI    | GE <sub>6</sub> | 7°            |
| Vol V No. 36    | 'Obv. II 21' |       |                 | 4°            |
| Diary No. -240  | 'Obv. 13'    | IX    | GE <sub>6</sub> | 11° 50'       |
| Vol V No. 40    | 'Rev.' II 4' |       |                 | 11° 40'       |
| Diary No. -187A | Obv.' 6      | VII   | ŠÚ              | 15° 40'       |
| Vol V No. 42    | Obv. IV 2    |       |                 | 15° 30'       |
| Diary No. -187A | Obv.' 7      | VII   | <i>na</i>       | 4° 10+[x'...] |
| Vol V No. 42    | Obv. IV 3    |       |                 | 2° 50'        |
| Diary No. -187B | 'Obv. 3'     | XI    | ME              | 7° 30'        |
| Vol V No. 42    | Rev. VI 2    |       |                 | 6° 40'        |
| Diary No. -187B | 'Obv. 4'     | XI    | ŠÚ              | 1° 30'        |
| Vol V No. 42    | Rev. VI 3    |       |                 | 1°            |
| Diary No. -187B | 'Obv. 4'     | XI    | GE <sub>6</sub> | 6° 30'        |
| Vol V No. 42    | Rev. VI 4    |       |                 | 6° 20'        |
| Diary No. -187A | 'Rev. 24'    | XII   | ME              | 2°            |
| Vol V No. 42    | Rev. VI 9    |       |                 | 1° 40'        |
| Diary No. -187A | 'Rev. 24'    | XII   | GE <sub>6</sub> | 11°           |
| Vol V No. 42    | Rev. VI 8    |       |                 | 13° 50'       |

**Table 2.4: details of records where Diaries report different Lunar 6 measurements for the same event taken from either the Astronomical Diary translations in ADART Vols I-III, or the Diary excerpts in ADART Vol. V.**

| Text no.            |                 | Date                           | Event   |
|---------------------|-----------------|--------------------------------|---|
| -209 C              | 'Obv. 4'-5'     | Night of the 9th [...]         | Mercury was 1 5/6 cubits above $\eta$ Geminorum                                       |
| -209 D              | 'Obv. 6'        | [Night of the 10th]            | Mercury was [...] above [ $\eta$ Geminorum ...]                                       |
| -209 C              | 'Obv. 10'       | [Night of the 14th]            | Mercury 1 <sup>2</sup> cubit 8 <sup>2</sup> fingers above $\gamma$ Geminorum          |
| -209 D              | 'Obv. 10'       | Night of the 16th              | Mercury was 1 1/2 <sup>2</sup> cubits above $\gamma$ Geminorum                        |
| -209 C              | Rev.' 1         | [Night of the 22nd]            | [Ve]nus was 2 1/2 cubits below $\beta$ Geminorum                                      |
| -209 D              | 'Obv. 12'       | Night of the 23rd <sup>2</sup> | Venus was 2 1/2 cubits below $\beta$ Geminorum  |
| -209 C              | Rev.' 2         | On the 22nd                    | Saturn's first appearance in the beginning of Taurus                                  |
| -209 D              | 'Obv. 13'       | Night of the 23rd <sup>2</sup> | [... Saturn's first appearance in Taurus ...] (ideal)<br>first appearance on the 22nd |
| -143 A              | 'Flake' 29'-30' | Night of the 17th              | [Saturn was] 1/2 cubit [above $\rho$ Leoni]s  |
| -143 B              | 'Obv. 5'        | [Night of the 18th ...]        | Saturn was [...] above [ $\rho$ Leonis ...]   |
| -119 A <sub>2</sub> | Obv.' 13'       | Around the 26th <sup>sc</sup>  | Venus' [first appearance] in the east [in Taurus]                                     |
| -119 B <sub>1</sub> | 'Obv.' 9'       | Around the 25th                | Venus' first appearance in the east in Taurus   |
| -105 A              | 'Obv.' 35'      | Around the 6th                 | Mercury's last appearance in the west in Cancer                                       |
| -105 A              | 'Obv.' 45'      | On the 5th                     | Mercury's last appearance in the west in Cancer                                       |
| -105 B              | 'Obv.' 32'      | Around the 5th                 | Mercury's last appearance in the west in Cancer                                       |

**Table 2.5: details of records where Diaries report different dates for the same planetary event.**

## 2.2 The Goal-Year Texts

Goal-Year Texts are a compilation of planetary and lunar records taken from particular years,<sup>99</sup> which use the periodic motions of the planets to make rough predictions of the events for a particular year (the “goal year”). A typical Goal-Year Text has 8 sections, with each section devoted solely to records involving a particular planet (or the Moon) from a specific year. As discussed in the previous chapter, the planetary sections are always presented in the conventional order: Jupiter’s phenomena, Jupiter’s passages, Venus, Mercury, Saturn, Mars’ phenomena, Mars’ passages; the lunar section may come before or after the planetary section.

Table 2.6 shows which periods were used for each type of event. For Jupiter and Mars, a different period was used for Greek-letter phenomena and Normal Star passages. For all the other planets, the same period was used for both types of event.

So a Goal-Year Text predicting goal year Y will have a section containing Jupiter records from the year Y-71, followed by a section containing Jupiter records from the year Y-83, a section containing Venus records from the year Y-8, and so on. All in all it would have been necessary to consult Diaries from at least nine different years in the compilation of each Goal-Year Text.<sup>100</sup>

| Planet                 | Observation type       | Period in Babylonian years |
|------------------------|------------------------|----------------------------|
| Mercury                |                        | 46                         |
| Venus                  |                        | 8                          |
| Mars                   | Greek-letter phenomena | 79                         |
| Mars                   | Planetary passages     | 47                         |
| Jupiter                | Greek-letter phenomena | 71                         |
| Jupiter                | Planetary passages     | 83                         |
| Saturn                 |                        | 59                         |
| Lunar Six and eclipses |                        | 18                         |
| Sums of Lunar Four     |                        | 18 ½                       |

**Table 2.6: The Goal-Year periods, used in the Goal-Year Texts**

## 2.3 The Normal Star Almanacs

The Normal Star Almanacs are a type of predictive text which was used during the Seleucid Era; the earliest available Normal Star Almanac is dated to year SE 19 (293-292 B.C.) and the latest to year SE 234 (78-77 B.C.). A Normal Star Almanac typically contains predictions of:

- Dates and distance measurements of the planets’ passages by Normal Stars,
- Dates and (usually) zodiacal signs of the planets’ Greek-letter phenomena,
- Dates and timings of the Lunar Six, or occasionally the Lunar Three,
- Dates and timings of eclipses, or eclipse possibilities,
- Dates of solstices, equinoxes, and Sirius’ Greek-letter phenomena,
- In rare cases a Normal Star Almanac also contains dates on which a planet reaches a new zodiacal sign.

<sup>99</sup> Commonly assumed to be excerpts from particular Astronomical Diaries – see “The source of the Goal-Year Texts’ records” later in this chapter.

<sup>100</sup> Some Goal-Year Texts also include records from a month or two before or after the observations year. For example, there would be Venus records from year Y-8, and possibly records from the end of year Y-9, or the beginning of year Y-7. This is discussed in detail in Chapter 6.

Note that these are all events of a periodic nature, each of which is also recorded in the Diaries and related texts. As described in Chapter 1, this has led to the suggestion that the Normal Star Almanacs' predictions were derived from observations in the Diaries; this will be examined in more detail later in this chapter, and in Chapter 5.

Unlike the Astronomical Diaries and the Goal-Year Texts, there has been as yet no exhaustive collection and translation of the Normal Star Almanacs.<sup>101</sup> Table 2.7 is a record of the Normal Star Almanacs which were consulted during this research. Where the text was not simply translated from a copy in LBAT, the table shows whether the text had been previously translated, or whether I have translated it from somebody else's copy or from viewing the tablet itself.

| Year (SE) | Museum number                  | LBAT number | Other notes                                      |
|-----------|--------------------------------|-------------|--|
| 19        | BM 48104                       |             | transliterated by John Steele                    |
| 31        | BM 47724                       | *995        | transliterated by John Steele                    |
| 40        | BM 32321+                      |             | text viewed in person                            |
| 51?       | BM 34900+                      | 996         | text viewed in person                            |
| 55        | BM 32847+                      | *997, 998   | text viewed in person                            |
| 58        | BM 47816                       | *999        | text viewed in person                            |
| 60        | BM 33989                       | 1000        |  |
| 68        | BM 42076                       | 1001        |  |
|           | BM 40626                       |             | text viewed in person                            |
| 70        | MM 86.11.369                   | *1001a      | Transliteration and translation by Walker (2005) |
| 80        | BM 42135                       | 1002        |  |
| 82        | Rm 731+                        | *1003       | text viewed in person                            |
|           | MLC 1860                       | *1004       | transliterated by John Steele                    |
| 92        | BM 41880                       | 1005        |  |
| 93        | BM 41634+                      | 1006        |  |
| 96        | Columbia University Library 6x | **1007      | Copy in Goetze (1947)                            |
|           | BM 41588+                      | 1008        |  |
|           | BM 47869                       |             |  |
| 99        | CBS 499                        |             | transliterated by John Steele                    |
| 101       | Rm 755                         | *1009       |  |

<sup>101</sup> Full editions of the Normal Star Almanacs are in preparation by Hunger as *ADART* Vol. VII.

| Year<br>(SE) | Museum number     | LBAT number                   | Other notes                      |
|--------------|-------------------|-------------------------------|----------------------------------|
|              | BM 32522          | *1009a                        |                                  |
|              | BCMA 1846-1982    |                               | transliterated by John Steele    |
| 104          | BM 34080          | 1010                          |                                  |
| 105          | BM 40625          | *1011                         | text viewed in person            |
|              | BM 41545+, 132283 | 1012                          |                                  |
| 106          | BM 41022+         | *1013-4                       | transliterated by John Steele    |
|              | BM 41846          | 1015                          |                                  |
| 107          | BM 41520+         | 1016-8                        |                                  |
| 108          | BM 33987          | 1019                          |                                  |
| 109          | BM 41117          |                               | text viewed in person            |
| 111          | BM 45696          | 1020                          | Copy also in SSB II              |
| 113          | BM 47909          |                               | text viewed in person            |
| 116          | BM 35542+         | 1021, 1087, 1090              |                                  |
| 120          | BM 41599          | 1022                          | Copy also in SSB I               |
| 121          | BM 33450          | *1023                         | text viewed in person            |
| 125          | BM 35817          | 1024                          |                                  |
| 128          | BM 47738          | *1024a                        | transliterated by John Steele    |
| 133          | MLC 1885          | *1025                         | transliterated by John Steele    |
| 135          | BM 34228          | 1026                          |                                  |
| 137          | BM 35581+         | 1027-8, 1091-2, 1094,<br>1101 |                                  |
| 142          | BM 41106          | *1028a                        | text viewed in person            |
| 146          | BM 34116+         | 1029-30                       |                                  |
| 150          | Ist. U. 193a+     | *1030a                        | transliterated by Hermann Hunger |
| 151          | Ist. U. 194       | *1031                         |                                  |
| 156          | AO 8530           | *1032                         | transliterated by Hermann Hunger |
| 157          | BM 46210          | *1033                         | text viewed in person            |
| 157-8        | BM 34888+         | 1034-5, *1036, 1037,<br>1093  | text viewed in person            |
| 159          | BM 32088          |                               | text viewed in person            |
| 172          | BM 34076+         | 1038                          | Copy also in SSB II              |

| Year<br>(SE) | Museum number | LBAT number   | Other notes  |
|--------------|---------------|---------------|--|
| 173          | BM 34199      | 1039          |  |
| 175          | BM 32769+     | *1040, 1041-2 | transliterated by John Steele                      |
| 177          | BM 35090      | 1076          |  |
| 178          | BM 33482+     | *1042a-c      | text viewed in person                              |
| 179          | BM 34056+     | 1043-4        |  |
| 183          | BM 33448+     | *1045-6+1138  | text viewed in person                              |
| 184          | BM 34054      | 1047          |  |
|              | BM 34620      | 1048          |  |
| 187          | BM 34868+     | 1049-50       |  |
|              | BM 35372      | 1082          |  |
| 188          | BM 34078      | 1051          |  |
|              | BM 34588      | 1052          |  |
|              | BM 34395      | 1053          |  |
|              | BM 35623+     | *1054+1097    | transliterated by John Steele                      |
| 189          | BM 34033      | **1055        | Copy in AAB  |
| 190          | BM 48072      |               | text viewed in person                              |
| 192          | BM 35637+     | 1056          |  |
| 194          | BM 34758      | 1057          |  |
| 195          | BM 34229      | 1058          |  |
| 201          | BM 34032      | **1059        | Copy in AAB  |
| 203          | BM 35340      | 1060          |  |
| 203?         | BM 37493      |               |  |
| 208          | BM 32230      |               | transliterated by John Steele                      |
| 210          | BM 34607      | 1061          |  |
| 212          | BM 35059+     | 1062-5        |  |
| 234          | BM 32247      |               | Transliteration and translation by Roughton (2002) |

**Table 2.7: Provenance of the extant Normal Star Almanacs, showing whether they are copied in LBAT or elsewhere.**

## 2.4 The Almanacs

Another type of predictive text in use during the Seleucid Era was the Almanac. The earliest Almanac has been dated to SE 92 (220-219 B.C.) and the latest to SE 385 (AD 74-75) and, as with the Normal Star Almanacs, all the types of events predicted in the Almanacs could have been derived from the Diaries. However, it is an interesting artefact of the texts which have survived to our time that none of the remaining Diaries could have been used in predicting the records in the latest dated Almanacs.<sup>102</sup>

An Almanac's contents typically include:

The planets' zodiacal signs at the start of each month, and dates on which a planet reaches a new zodiacal sign,  
 Dates of the Lunar Three,  
 Dates and (usually) zodiacal signs of the planets' Greek-letter phenomena,  
 Dates and timings of eclipses, or eclipse possibilities,  
 Dates of solstices, equinoxes, and Sirius' Greek-letter phenomena.

As with the Normal Star Almanacs, a full edition of the Almanacs will be found in *ADART* Vol. VII; but as yet there has been no exhaustive collection and translation. Table 2.8 is a record of the Almanacs which were consulted during this research. As with Table 2.7, where the text was not simply translated from a copy in LBAT, the table shows whether the text had been previously translated, or whether I have translated it from somebody else's copy or from viewing the tablet itself.

| Year (SE) | Museum number | LBAT number | Other notes                   |
|-----------|---------------|-------------|-------------------------------|
| 92        | BM 40101+     | *1118-9     | text viewed in person         |
| 127       | BM 32888      | *1120       | transliterated by John Steele |
|           | Rm 786        | 1121        |                               |
| 128       | BM 34232      | 1122        | Copy also in SSB II           |
| 129       | BM 33873      | **1123      | Copy in SSB I                 |
| 147       | MLC 2195      | *1124       | transliterated by John Steele |
| 157       | BM 35894      | 1125        |                               |
|           | BM 34470      | 1126        |                               |
| 158       | BM 34121      | 1127        | Copy also in SSB II           |
| 159       | BM 41010      | *1128       | text viewed in person         |
| 160       | BM 34345      | 1129        | Copy also in SSB II           |
| 162       | BM 35729      | 1130        |                               |
| 168       | BM 35093+     | 1131        |                               |
| 175       | BM 35366+     | 1132-3      |                               |

<sup>102</sup> The latest dated Diary is for year SE 251 (61-60 B.C.). Assuming Goal-Year methods, the earliest Diary that could have been used to create the Almanac for SE 385 would have been the Diary for 83 years previously, i.e. SE 302 (10-9 B.C.). See also Figure 2.1.

| Year (SE) | Museum number | LBAT number               | Other notes                      |
|-----------|---------------|---------------------------|----------------------------------|
| 178       | BM 34051      | 1134                      | Copy also in SSB I & II          |
| 179       | BM 33867      | 1135                      |                                  |
|           | BM 46106      | 1136                      |                                  |
| 183       | BM 35551      | 1137                      |                                  |
| 185       | BM 34949      | 1139                      | Copy also in SSB II              |
| 186       | BM 46255      | *1140                     | transliterated by Hermann Hunger |
| 189       | BM 45827+     | 1141-2                    |                                  |
| 190       | BM 34298      | 1143                      |                                  |
|           | BM 45839      | 1144                      |                                  |
| 195       | BM 35620      | *1145                     | text viewed in person            |
|           | BM 45972      | *1146                     | text viewed in person            |
| 197       | BM 45716      | *1147                     | transliterated by John Steele    |
| 198       | BM 35187+     | 1148-9                    |                                  |
| 200       | BM 38212      | *1150                     | transliterated by John Steele    |
| 201       | BM 35562      | 1151                      |                                  |
| 209       | BM 33641      | 1152                      |                                  |
|           | BM 34042      | 1153                      | Copy also in SSB II              |
|           | BM 34991+     | 1154-5, *1156             | Copies of 1154-5 also in SSB II  |
| 220       | BM 35149      | 1157                      | Copy also in SSB II              |
|           | BM 35039      | 1158                      | Copy also in SSB II              |
| 226       | BM 36016+     | 1159                      |                                  |
| 233       | BM 35720      | 1160                      |                                  |
| 234       | BM 33633      | **1161                    | Copy in SSB II                   |
|           | BM 35707+     | 1162-3                    |                                  |
|           | BM 34667+     | 1164-5, *1166             |                                  |
|           | BM 45953+     | **1167-8                  | Copy in SSB II                   |
|           | BM 77257      |                           | text viewed in person            |
|           | BM 45929      |                           |                                  |
| 236       | BM 43722      | 1169                      | Copy in SSB II                   |
|           | BM 35098      | 1170                      |                                  |
|           | BM 35314+     | 1171, 1205, 1209,<br>1173 |                                  |
|           | BM 33746+     | **1172+1117               | Copy of **1172 in SSB II         |



| Year (SE) | Museum number   | LBAT number | Other notes   |
|-----------|-----------------|-------------|---|
|           | BM 45698        | 1174        | Copy also in SSB II   |
| 237       | BM 33736        | 1175        |   |
| 241       | BM 45919        | 1176        |   |
| 242       | BM 40496        |             | text viewed in person                                       |
| 244       | BM 41900+       | 1177        |   |
|           | BM 46043        | 1178        |   |
| 245       | BM 31592+       | *1179-80    | transliterated by Hermann Hunger                            |
| 246       | BM 45729        | *1181       | transliterated by Hermann Hunger                            |
| 247       | BM 33798        | 1182        |   |
| 248       | BM 33485+       | 1183        |   |
| 254       | BM 46050        | 1184        |   |
| 282       | BM 34159        | 1185        |   |
| 291?      | BM 46105        | 1186        |   |
| 297       | BM 41468        | 1187        |   |
| 300       | BM 35570+       | 1188-9      |   |
| 301       | BM 33797        | **1190      | Copy in SSB I   |
| 303       | BM 33784+       | **1191-2    | Copy in SSB II  |
| 305       | BM 34614        | 1193        | Translation in Sachs & Walker (1984)                        |
|           | BM 34659        | 1194        | Translation in Sachs & Walker (1984)                        |
|           | BM 35429        | 1195        | Translation in Sachs & Walker (1984)                        |
|           | VAT 290+1836    | **1196      | Transliteration and (German) translation in Schnabel (1925) |
| 342       | MM 86.11.354    |             | Transliteration and translation in Sachs (1976)             |
| 347       | DT 143          | *1197       | Transliteration and translation in Sachs (1976)             |
| 355       | BM 45982        | *1198       | Transliteration and translation in Sachs (1976)             |
| 372       | BM 40083        | *1199       | Transliteration and translation in Sachs (1976)             |
|           | BM 40084        | 1200        | Transliteration and translation in Sachs (1976)             |
| 385       | Dropsie College | *1201       | Transliteration and translation in Sachs (1976)             |

**Table 2.8: Provenance of the extant Almanacs, showing whether they are copied in LBAT or elsewhere.**

## 2.5 Other texts

This broad category covers various other non-mathematical texts which do not fall into the above classifications. Unlike the above categories, it is difficult to generalise on the contents of these diverse texts. In general the texts either record lunar events, i.e. Lunar Six or eclipses (or both); or planetary events, i.e. Normal Star passages or planetary phenomena (or both) relating to, typically, one or two planets for some years. The timespan of the records collected in a lunar or planetary text can vary from one year to 70 years or more.

In many cases, as with the Goal-Year Texts, the records seem to have been copied directly from Astronomical Diaries. However, several of the texts focus on events which are not generally recorded in the Diaries, such as Mercury's stationary points<sup>103</sup> or longitudes of planetary phenomena.<sup>104</sup> Additionally, it is clear that some of the texts contain predictions and computations rather than copies of Diary observations. Most interesting are those, such as the Cambyse text,<sup>105</sup> which appear to contain data predicted using Goal-Year methods. This text mainly covers the events of year 7 of Cambyse's reign (-522/-521), nearly 300 years before the earliest extant Goal-Year Text. The fact that Goal-Year methods seem to have been in use from such an early date is obviously very intriguing, and useful for tracing the development of Goal-Year methods throughout the period – this will be discussed further in Chapter 4.

## 2.6 Timeline

We can be practically certain that the Babylonian astronomers would have been expected to produce Diaries and predictive texts for each year that they were employed. Certainly, it appears that astronomers producing Goal-Year Texts had a practically complete archive of former Diaries to work from.<sup>106</sup> However, as established earlier, only a small percentage of these texts are still in existence.<sup>107</sup> A lot of the research presented here involves comparing records in the different text types, and so it is important to show how relatively little overlap there is between the texts. Figure 2.1 shows to which years during the Late Babylonian period a Diary, Goal-Year Text, Normal Star Almanac or Almanac has been dated, from -400 to 75 AD.<sup>108</sup>

The figure shows that, although the various non-mathematical texts span the entire period, very few of them are pre-Seleucid. All of the pre-Seleucid texts are Diaries, although the earliest dated Goal-Year Texts would have included some pre-Seleucid Mars and Jupiter records. Note that, even when the Diaries become relatively plentiful in the 4<sup>th</sup> century B.C., it is a full century before the earliest example of another text type is dated. Also, note that the Almanacs generally are dated to much later on in the period, with the latest Almanacs having a date of more than 100 years after the latest examples of any of the other text types. This has obvious implications for the amount of possible overlap between the text types.

Nevertheless, in the 2<sup>nd</sup> and 3<sup>rd</sup> centuries B.C. texts covering overlapping years are

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<sup>103</sup> *ADART* Vol. V, No. 85.

<sup>104</sup> *ADART* Vol. V, No. 74. Analysed in Steele (2000c).

<sup>105</sup> *ADART* Vol. V, No. 55, see Britton (2007b) for a full analysis.

<sup>106</sup> The very few cases where a Diary was clearly *not* available, demonstrated with a remark such as “Year 2 [...] the passages of Jupiter in Aquarius and Pisces are missing” (*ADART* Vol. VI No. 7, Obv. 3), only serve to highlight that the Babylonian astronomers almost always had all the past records that they needed.

<sup>107</sup> Hunger (1999) estimates around 5%.

<sup>108</sup> This figure follows Sachs (1974), Figure 2 of which is an equivalent timeline showing only the dates of Astronomical Diaries. Since the publication of that paper a few more Diaries have been identified and dated, and some have been redated; however the general trend of Sachs' figure is still applicable now.

common. Some years (SE 158 and 175) even have all four text types still in existence. Of course, it is also important to remember that many of the texts are damaged or partially broken away, and Diaries cover less than a full year in any case; so even when different types of text exist for the same year, there is no certainty that their remaining records will necessarily overlap.

Note: Diaries also exist for years:  
-651, -567, -463, -453 and -418

D=Diaries, G=GYT, N=NSA,  
A=Almanac

| Year | D | G | N | A | SE |
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| -400 |   |   |   |   |    |
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| Year | D | G | N | A | SE  |
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| Year | D | G | N | A | SE  |
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| -8   |   |   |   |   | 303 |
| -7   |   |   |   |   | 304 |
| -6   |   |   |   |   | 305 |
| -5   |   |   |   |   | 306 |
| -4   |   |   |   |   | 307 |
| -3   |   |   |   |   | 308 |
| -2   |   |   |   |   | 309 |
| -1   |   |   |   |   | 310 |
| 0    |   |   |   |   | 311 |
| 1    |   |   |   |   | 312 |
| 2    |   |   |   |   | 313 |
| 3    |   |   |   |   | 314 |
| 4    |   |   |   |   | 315 |
| 5    |   |   |   |   | 316 |
| 6    |   |   |   |   | 317 |
| 7    |   |   |   |   | 318 |
| 8    |   |   |   |   | 319 |
| 9    |   |   |   |   | 320 |
| 10   |   |   |   |   | 321 |
| 11   |   |   |   |   | 322 |
| 12   |   |   |   |   | 323 |
| 13   |   |   |   |   | 324 |
| 14   |   |   |   |   | 325 |
| 15   |   |   |   |   | 326 |
| 16   |   |   |   |   | 327 |
| 17   |   |   |   |   | 328 |
| 18   |   |   |   |   | 329 |
| 19   |   |   |   |   | 330 |
| 20   |   |   |   |   | 331 |
| 21   |   |   |   |   | 332 |
| 22   |   |   |   |   | 333 |
| 23   |   |   |   |   | 334 |
| 24   |   |   |   |   | 335 |
| 25   |   |   |   |   | 336 |
| 26   |   |   |   |   | 337 |
| 27   |   |   |   |   | 338 |
| 28   |   |   |   |   | 339 |
| 29   |   |   |   |   | 340 |
| 30   |   |   |   |   | 341 |
| 31   |   |   |   |   | 342 |
| 32   |   |   |   |   | 343 |
| 33   |   |   |   |   | 344 |
| 34   |   |   |   |   | 345 |



| Year | D | G | N | A | SE  |
|------|---|---|---|---|-----|
| 35   |   |   |   |   | 346 |
| 36   |   |   |   |   | 347 |
| 37   |   |   |   |   | 348 |
| 38   |   |   |   |   | 349 |
| 39   |   |   |   |   | 350 |
| 40   |   |   |   |   | 351 |
| 41   |   |   |   |   | 352 |
| 42   |   |   |   |   | 353 |
| 43   |   |   |   |   | 354 |
| 44   |   |   |   |   | 355 |
| 45   |   |   |   |   | 356 |
| 46   |   |   |   |   | 357 |
| 47   |   |   |   |   | 358 |
| 48   |   |   |   |   | 359 |
| 49   |   |   |   |   | 360 |
| 50   |   |   |   |   | 361 |
| 51   |   |   |   |   | 362 |
| 52   |   |   |   |   | 363 |
| 53   |   |   |   |   | 364 |
| 54   |   |   |   |   | 365 |
| 55   |   |   |   |   | 366 |
| 56   |   |   |   |   | 367 |
| 57   |   |   |   |   | 368 |
| 58   |   |   |   |   | 369 |
| 59   |   |   |   |   | 370 |
| 60   |   |   |   |   | 371 |
| 61   |   |   |   |   | 372 |
| 62   |   |   |   |   | 373 |
| 63   |   |   |   |   | 374 |
| 64   |   |   |   |   | 375 |
| 65   |   |   |   |   | 376 |
| 66   |   |   |   |   | 377 |
| 67   |   |   |   |   | 378 |
| 68   |   |   |   |   | 379 |
| 69   |   |   |   |   | 380 |
| 70   |   |   |   |   | 381 |
| 71   |   |   |   |   | 382 |
| 72   |   |   |   |   | 383 |
| 73   |   |   |   |   | 384 |
| 74   |   |   |   |   | 385 |
| 75   |   |   |   |   | 386 |

Figure 2.1: a timeline of Babylonian years from -400 to 75 AD, showing to which years an extant Astronomical Diary, Goal-Year Text, Normal Star Almanac or Almanac has been dated. Note that there is only a particularly significant overlap in the 3rd and 2nd centuries BC.

## 2.7 The source of the Goal-Year Texts' records

As stated above, it is normally assumed that the records in the Goal-Year Texts were copied from the Astronomical Diaries.<sup>109</sup> Table 2.9 shows the result of comparing 70 records of the same event, found in a Diary and a Goal-Year Text. Only records where a date and/or a distance measurement was preserved in each text were considered. The full details of the records can be found in Appendix B.

| Planet  | Number of comparisons |          |              |
|---------|-----------------------|----------|--------------|
|         | Total                 | Matching | Not matching |
| Jupiter | 5                     | 3        | 2            |
| Venus   | 21                    | 17       | 4            |
| Mercury | 28                    | 21       | 7            |
| Saturn  | 9                     | 8        | 1            |
| Mars    | 7                     | 5        | 2            |
| All     | 70                    | 54       | 16           |

**Table 2.9: a summary of comparisons of Diary and Goal Year Text records, to show whether the planetary record in the two texts matches or not.**

Comparing the entries shows that often a Diary and a Goal-Year Text contain exactly the same record, word-for-word. In these cases the Goal-Year Text records must almost certainly have been copied from the Diary. However, in a lot of cases the recorded date or distance varies in the two texts; yet, this does not rule out the Diary being the source of these records too. As established in §2.1.3, when multiple observers were involved in carrying out observations they could often disagree regarding measured distances or times of events, and less often regarding dates of events (see Tables 2.3 - 2.5). It could be that the Goal-Year Text was copied from a near-duplicate Diary which no longer exists.

Equally, one text often gives a detailed, verbose account of an event while the other has an extremely short, terse entry for the same event. Again, this does not rule out a connection between the two texts. A few examples, taken from Appendix B, will illustrate this further:

14 GU<sub>4</sub>-UD *ina* ŠÚ *ina* ABSIN 2 ½ KÙŠ *ár dele-bat ana* ŠÚ GUB IGI  
KUR NIM-*a* 16 *na-su in* 12 IGI

“The 14<sup>th</sup>, Mercury’s first appearance in the west in Virgo, it stood 2 ½ cubits behind Venus to the west<sup>sic</sup>; it was bright (and) high, sunset to setting of Mercury: 16°; (ideal) first appearance on the 12<sup>th</sup>.”  
(*ADART* Vol. II No. -186C, Rev. 11-12)

ZÍZ 14 GU<sub>4</sub>-UD *ina* ŠÚ *ina* *zib<sup>mc</sup>* 2 ½ KÙŠ *ár dele-bat ana* N[IM GUB  
IGI KU]R NIM-*a* 16 *na-su in* 12 IGI

“Month XI, the 14<sup>th</sup>, Mercury’s [first appearance] in the west in Pisces, [it stood] 2 ½ cubits behind Venus to the east; [it was bright (and) high, sunset to setting of Mercury: 16°; (ideal) first appearance on the 12<sup>th</sup>.”  
(*ADART* Vol. VI No. 53, Obv. 20’-21’)

The Diary entry in this case comes from an end-of-month planetary summary. The two records are clearly extremely similar; the only difference is the relevant zodiacal sign, and

<sup>109</sup> For example Kugler (1924), Sachs (1948) onwards.

other nearby records show that “Virgo” is an error for “Pisces” here.

*in* 14 GU<sub>4</sub>-UD *ina* NIM *ina* TIL GU ŠÚ

“Around the 14<sup>th</sup>, Mercury’s last appearance in the east in the end of Aquarius.”

(*ADART* Vol. III No. -163C<sub>1</sub>, Rev. 3’)

[Š]E 17 ŠÚ šá GU<sub>4</sub>-UD *ina* NI]M [*ina*] šib<sup>me</sup> TA 14 *ina* TIL GU *ki* PAP  
NU IGI

“[Month] XII, the 17<sup>th</sup>, Mercury’s last appearance [in the ea]st [in] Pisces: from the 14<sup>th</sup> in the end of Aquarius, when I watched I did not see it.”

(*ADART* Vol. VI No. 69, Obv. 31-32)

The Diary entry again comes from an end-of-month planetary summary, and is notably briefer than the Goal-Year Text’s entry.

§2.1.2, concerning planetary summaries, showed that the planetary summary at the end of a month could record a different dates for the same Greek-letter phenomenon than the observation during the month, particular when an “ideal” date was also recorded. The above examples, and the further examples in Appendix B, demonstrate that some Goal-Year Texts copied the observed date of a planetary event from a Diary, and some copied the ideal date.

These results match the findings of Hunger.<sup>110</sup> He compared 93 Diary and Goal-Year Text records of the same event and found differences in 20 cases. In the same paper he also warns that he previously “restored broken passages in the edition of the Diaries from a corresponding Goal year text” but that he is “not so sure about the certainty of restoring anymore”<sup>111</sup>! For the text comparisons outlined in this work, it is important to be aware of when modern scholars have restored broken passages. Evidently, if we wish to develop an understanding of Babylonian astronomical methods it is particularly crucial to know whether numbers and measurements to be analysed come from Babylonian writing or modern restorations.

## ***2.8 The source of the Normal Star Almanacs’ and Almanacs’ records***

There are no “instruction manuals” remaining to tell us how the Babylonian Astronomers produced the predictions in the Normal Star Almanacs and Almanacs. However, the events they predict are all of a periodic nature so we can be reasonably sure that any method employed to make the predictions would have made use of their periodicity. With this in mind, we can consider a few theories, outlined in Chapter 1, concerning the origins of the predictive texts.

One possibility is that the predictions were derived using the mathematical ephemerides found in *ACT*.<sup>112</sup> A few of the remaining extant Normal Star Almanacs or Almanacs cover years which overlap with ephemerides texts, and so the dates of Greek-letter phenomena predicted in the texts and in the *ACT* schemes can be compared. Table 2.10 summarises the results of these comparisons, and the full details of the records being compared can be found in Appendix C.

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<sup>110</sup> Hunger (1999).

<sup>111</sup> Hunger (1999), p. 83.

<sup>112</sup> Neugebauer (1955).

| Planet  | System         | Number of comparisons |          |              | Percentage matching |
|---------|----------------|-----------------------|----------|--------------|---------------------|
|         |                | Total                 | Matching | Not Matching |                     |
| Mercury | A <sub>2</sub> | 0                     |          |              |                     |
| Mercury | A <sub>1</sub> | 58                    | 10       | 48           | 17.24%              |
| Venus   | A <sub>0</sub> | 2                     | 0        | 2            | 0.00%               |
| Venus   | A <sub>1</sub> | 3                     | 1        | 2            | 33.33%              |
| Venus   | A <sub>2</sub> | 9                     | 3        | 6            | 33.33%              |
| Mars    | A              | 4                     | 0        | 4            | 0.00%               |
| Jupiter | A              | 24                    | 1        | 23           | 4.17%               |
| Jupiter | A'             | 38                    | 2        | 36           | 5.26%               |
| Jupiter | B              | 16                    | 0        | 16           | 0.00%               |
| Jupiter | B'             | 1                     | 0        | 1            | 0.00%               |
| Saturn  |                | 3                     | 0        | 3            | 0.00%               |

**Table 2.10: comparisons of Greek-letter phenomena predictions from the Normal Star Almanacs or Almanacs with ACT ephemerides, showing whether the date of a planetary event predicted in these two types of text matches or not**

It is immediately clear from Table 2.10 that the *ACT* ephemerides were *not* the source of the Normal Star Almanacs' or Almanacs' predictions of Greek-letter phenomena. The dates of events rarely agree, and are on occasion significantly different – 12 days or more. The only possible correlation is for Mars, System A where all of the phenomena dates are 6 days earlier in the predictive texts than in the *ACT* ephemerides. However, given that this result is derived from comparing the mere four available record pairs, it is certainly not a large enough amount of data to draw any further conclusions. In total around 10% of the comparisons agree on the date of an event, which is as much as we might expect the dates to overlap by coincidence.

An additional problem is that the *ACT* schemes do not directly predict passages of planets by Normal Stars, which would be necessary for the creation of Normal Star Almanacs. It seems that this would have been a more complicated process than calculating Greek-letter phenomena. Firstly, the daily longitude of the planet would have to be computed; these longitudes could then be compared with a star catalogue to determine the dates when the planet passed a Normal Star. An extremely small number of the ephemeris texts calculate the daily motion of Mercury or Jupiter,<sup>113</sup> and it is possible that texts existed to calculate the motions of the other planets too, but it seems that this process would have been somewhat laborious. According to Neugebauer the daily longitudes in these texts were calculated by interpolating between dates and longitudes of Greek-letter phenomena, in a scheme involving both the first and second derivatives of the daily longitude.<sup>114</sup>

Secondly, the daily latitude of the planet would have to be computed, so that the distance between the planet and Normal Star at the time of the passage could be calculated; there is no evidence that these steps were taken with the *ACT* ephemerides. Therefore, the *ACT* ephemerides need not be considered further as a source of the Normal Star Almanacs' and Almanacs' predictions.

Another suggestion is that the predictions were derived empirically, i.e. from the planetary periods and records found in the Goal-Year Texts. The primary argument in favour of this is that Goal-Year Texts are arranged in separate sections for each planet, which is not very convenient to refer to during the goal year itself. Normal Star Almanacs and Almanacs contain the same types of records but in chronological order for the prediction year, and so logically one might suggest that they consist of Goal-Year Text data rewritten

<sup>113</sup> Neugebauer (1955), texts 310 and 650-655.

<sup>114</sup> See the commentaries to texts 310 and 654, in Neugebauer (1955) pp 326-328 and 354-355 respectively.

chronologically for ease of use.

The merits of this theory will be discussed at length in Chapters 5 and 6. An argument against the theory is that the Goal-Year Texts rarely give the dates of planets reaching new zodiacal signs, and never explicitly contain the planetary position summaries at the beginning or end of a month which the Almanacs predict. As discussed in the previous chapter, it is not known exactly how the zodiacal sign boundaries were determined in Babylonian astronomy, and so the planetary positions in the Almanacs could simply have been deduced by reference to the Greek-letter phenomenon and Normal Star passage records in the Goal-Year Texts. The issues of the zodiacal signs' boundaries is examined further in the following chapter.

## Chapter 3

### Some outstanding issues relating to planetary records

This chapter combines studies of several issues relating to the non-mathematical texts, which have not been completely solved in the previous literature. In this chapter, unlike the following chapters, the focus is not on matters directly relating to Goal-Year predictions of events, but instead on understanding the terminology of the records. The chapter covers the usage of specific stars in planetary passages and other contexts, and the ways in which the zodiacal signs were used.

#### 3.1 *The Normal Stars used in the predictive texts*

Alexander Jones has published an extensive study of the Normal Stars used in Babylonian planetary observations.<sup>115</sup> This section adds to Jones' investigation by comparing his findings with the Normal Stars used in Babylonian planetary *predictions*, i.e. predictions from the Normal Star Almanacs. (The Almanacs predict planetary positions using zodiacal signs only, so need not be considered here.)

It is not easy to define exactly how many Babylonian Normal Stars there are. As mentioned in Chapter 1, the introduction to *ADART* Vol. I details 32 Normal Stars, with the authors explaining that there are (unnamed and unnumbered) others used much less often. Star lists from the Late Babylonian Period may often include several stars not on Sachs & Hunger's list.<sup>116</sup> Roughton and Canzoneri discuss two groups of stars in Sagittarius, which seem to have been used almost exclusively for positions of stations and eclipses rather than planetary passages.<sup>117</sup> It appears that a group of four stars was treated as one "Normal Star" in this context.

To help resolve the potential confusion, Jones divides the Normal Stars into two categories: the 28 "core" stars, which are used regularly and referred to nearly every time a planet or the Moon moves past them; and the "additional" stars, those encountered significantly less frequently in the texts.<sup>118</sup> He further divides the additional stars into "alternates", stars which are located close to a core star and are occasionally used instead; star groups used for stations and eclipses rather than passages, as mentioned above; and stars or star groups which are simply referred to extremely infrequently.

The situation found in the Normal Star Almanacs is simpler than that of the observational texts. In total 31 stars are used for predicting planetary passages: all of the core 28 stars, and the additional stars  $\eta$  and  $\gamma$  Cancrī (used as alternatives to the core star  $\delta$  Cancrī) and  $\delta$  Scorpīi (used as an alternative to the core star  $\beta$  Scorpīi). The usage of these alternate stars is discussed in the following two subsections.

There are various reasons that none of the other additional stars were used for predictions. Firstly, the additional star  $\pi$  Scorpīi could also be regarded as an alternate to  $\beta$  Scorpīi, but only in relation to lunar passages:  $\pi$  Scorpīi is at a very negative latitude, hence only the Moon comes close to it and none of the planets. Given that the Normal Star Almanacs do

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<sup>115</sup> Jones (2004).

<sup>116</sup> See for example Roughton, Steele and Walker (2004).

<sup>117</sup> Roughton & Canzoneri (1992).

<sup>118</sup> Jones (2004), pp. 482-3.

not attempt to predict lunar passages,<sup>119</sup> it is not surprising that  $\pi$  Scorpii does not appear.

Secondly, unlike in the observational texts, positions are not always recorded for predictions of stations or eclipses, and when they are recorded it is in terms of the planets' zodiacal sign rather than relative to a Normal Star. (See the sections on zodiacal signs later in this chapter.) Therefore, the stars and star groups which are used solely for observations of these types of events would not be found in the predictive texts. As for the very rare stars which are only used once or twice for planetary positions in the Diaries, it is not surprising that they do not show up in the much smaller extant number of Normal Star Almanacs.

### 3.1.1 Alternate Normal Stars in Cancer

Table 3.1a shows the longitudes and latitudes of the four Normal Stars in Cancer, shown for years SE 11 and SE 311.<sup>120</sup> The stars fall naturally into two pairs –  $\eta$  and  $\theta$  Cancri both have approximately the same longitude, as do  $\gamma$  and  $\delta$  Cancri. This is reflected in the Babylonian names for these stars:

MÚL IGI šá ALLA šá SI/ULÛ = Front star of the Crab to the north/south, referring to  $\eta$  and  $\theta$  Cancri respectively;

MÚL ár šá ALLA šá SI/ULÛ = Rear star of the Crab to the north/south, referring to  $\gamma$  and  $\delta$  Cancri respectively.

Note that these star names differ from each other only in one or two key words. This would very likely have been a potential source of error and confusion for the Babylonian astronomers, as it can be for modern scholars: one broken or wrongly copied sign can make it impossible to distinguish  $\eta$  or  $\delta$  Cancri from  $\theta$  or  $\gamma$  Cancri.

|                 | Longitude/Latitude<br>at -300 (year SE 11) | Longitude/Latitude<br>at 0 (year SE 311) |
|-----------------|--|--|
| $\eta$ Cancri   | 93.5/1.4                                   | 97.6/1.4                                 |
| $\theta$ Cancri | 93.8/-0.1                                  | 98.0/-0.1                                |
| $\gamma$ Cancri | 95.6/3.0                                   | 99.8/3.0                                 |
| $\delta$ Cancri | 96.7/-0.0                                  | 100.9/0.0                                |

**Table 3.1a: the longitude and latitude of  $\eta$ ,  $\theta$ ,  $\gamma$  and  $\delta$  Cancri in the years -300 and 0 (Sachs & Hunger, 1988)**

Why was  $\delta$  Cancri used as the core star, and the other three only as alternatives to it? Jones points out that some earlier observational texts refer just to “the rear stars of the crab”,<sup>121</sup> and the convention of using  $\delta$  Cancri may simply have developed from this – using the brightest star out of a group as a reference point rather than the group as a whole. From Table 3.1a one might also speculate that  $\delta$  Cancri was used more because it has a latitude of zero, i.e. it is exactly on the ecliptic and all the planets would therefore pass it by fairly closely. However, this is not a wholly convincing explanation as all of the other stars also have latitudes reasonably close to the ecliptic.

<sup>119</sup> The Goal-Year methods used for predicting planetary passages would not be as effective for lunar passages. Goal-Year methods predict passages to the nearest day or so, but the Moon moves extremely fast – 12° of longitude or more a day – potentially passing by several Normal Stars in less than a day. Therefore it is much more difficult to predict empirically which Normal Star the Moon would be seen near on a given night.

<sup>120</sup> Longitude and latitude values taken from Sachs & Hunger (1988); all of the extant Normal Star Almanacs fall within these dates (see Table 2.6 in the previous chapter).

<sup>121</sup> Jones (2004), p. 485.

Whatever the reasons were, the use of  $\delta$  Cancri as a core star is certainly borne out by the records in the predictive texts. Table 3.1b lists the predictions of planets passing Normal Stars in Cancer, taken from the Normal Star Almanacs. There are 9 references to  $\delta$  Cancri, compared with only 2 for  $\eta$  Cancri, 1 for  $\gamma$  Cancri, and none at all for  $\theta$  Cancri. The table does not include any passages where the name of the Normal Star was broken, as discussed above.

| Date                        | Record                       | Planet's longitude | Planet's latitude |
|-----------------------------|------------------------------|--------------------|-------------------|
| Passages by $\eta$ Cancri   |                              |                    |                   |
| 188, I 30                   | Mars 4 fingers above         | 96.1               | 1.6               |
| 189, XII 18                 | Mars 2 fingers above         | 93.9               | 2.2               |
| Passages by $\gamma$ Cancri |                              |                    |                   |
| 188, II 7                   | Mars 1/2 cubit below         | 100.2              | 1.5               |
| Passage by $\delta$ Cancri  |                              |                    |                   |
| 96, V ~20                   | Venus 20 fingers above [sic] | 96.6               | -2.2              |
| 107, XII ~15                | Saturn 2 fingers above       | 98.6               | 0.4               |
| 133, IV 30                  | Venus 1 cubit above          | 96.5               | -0.4              |
| 146, V 6                    | Mars 10 fingers above        | 99.1               | 0.9               |
| 172, III 13                 | Mercury 2 fingers above      | 100.9              | 1.2               |
| 189, V 18                   | Venus 2 fingers above        | 99.5               | -0.1              |
| 189, XII 28                 | Mars 20 fingers above        | 98.5               | 2.1               |
| 201, III 1                  | Venus 1 cubit above          | 101.5              | 1.7               |
| 201, III 2                  | Mars 1/2 cubit above         | 100.9              | 1.2               |

**Table 3.1b: the longitude and latitude of planets on the dates of Normal Star Almanac predictions of passages by  $\eta$ ,  $\gamma$  and  $\delta$  Cancri**

The longitudes and latitudes in this table were taken from JPL's Horizons system,<sup>122</sup> calculated for the planet's position at midnight on the predicted date (or the date of closest approach when the date was broken). As always, the lack of available data prevents many conclusions being drawn from the table, particularly when the texts seem to contain several errors. For example, the two predicted distances for Mars' passages by  $\eta$  Cancri are inconsistent. Also, every one of the predictions involving  $\delta$  Cancri expects the planet to pass *above* the star, even though in a few of the cases the planets' latitude is significantly lower than the star's and it would surely be observed passing below the star instead.

Finally, it is interesting to compare Table 3.1b with Jones' statement that "There appear to be no instances in which even a slow planet is recorded as passing by a front star and a rear star in this quartet"<sup>123</sup> given that here there are two texts which exactly predict such an event. The Normal Star Almanacs for years SE 188 and 189 both predict Mars passing by a front star of the Crab, followed by a rear star a few days later.

### 3.1.2 Alternate Normal Stars in Scorpio

Table 3.2a shows the longitudes and latitudes of two of the Normal Stars in Scorpio, shown for years SE 11 and SE 311 as before. Note that, as with the stars in Cancer,  $\beta$  and  $\delta$  Scorpii fall on approximately the same longitude. In this case  $\beta$  Scorpii has a latitude notably closer to the ecliptic than  $\delta$  Scorpii, and so one would indeed expect that it was

<sup>122</sup> See §1.4.1 for discussion of this tool.

<sup>123</sup> Jones (2004), p. 485.



used more often.

|                  | Longitude/Latitude<br>at -300 (year SE 11) | Longitude/Latitude<br>at 0 (year SE 311) |
|------------------|--|--|
| $\beta$ Scorpii  | 211.2/1.3                                  | 215.4/1.3                                |
| $\delta$ Scorpii | 210.6/-1.7                                 | 214.7/-1.7                               |

**Table 3.2a: the longitude and latitude of  $\beta$  and  $\delta$  Scorpii in the years -300 and 0 (Sachs & Hunger, 1988)**

As with Cancer, Jones refers to early texts showing that these two stars (and  $\pi$  Scorpii) functioned as a single Normal Star referred to as the “head of the scorpion”.<sup>124</sup> Again, the Babylonian names of the stars reflect this:

MÚL MURUB<sub>4</sub> ŠÁ SAG GÍR-TAB = the middle star of the Scorpion’s head ( $\delta$  Scorpii);  
MÚL *e* ŠÁ SAG GÍR-TAB = the upper star of the Scorpion’s head ( $\beta$  Scorpii).

Table 3.2b lists the records from the Normal Star Almanacs which predict planets passing by  $\beta$  or  $\delta$  Scorpii; there are 8 references to  $\beta$  Scorpii and 4 references to  $\delta$  Scorpii. Again, this is consistent with  $\beta$  being the “core” star and  $\delta$  being the “alternate”.

| Date                         | Record                   | Planet's longitude | Planet's latitude |
|------------------------------|--------------------------|--------------------|-------------------|
| Passages by $\beta$ Scorpii  |                          |                    |                   |
| 96, IX 2                     | Venus 2 fingers above    | 212.1              | 1.6               |
| 104, VIII 29                 | Venus 2 fingers [...]    | 211.5              | 1.6               |
| 116, IX 28                   | Saturn 8 fingers above   | 214.9              | 2.3               |
| 133, VIII 5                  | Mercury 10 fingers above | 205.8              | 2.7               |
| 173 VIII [...]               | Mercury [...] above      | 213.2              | 1.6               |
| 184, IX 2                    | Mars [...] below         | 214.9              | 0.6               |
| 192, VIII 8                  | Venus [...] above        | 212.3              | 1.4               |
| 201, VIII 29                 | Mars 8 fingers below     | 216.9              | 0.3               |
| Passages by $\delta$ Scorpii |                          |                    |                   |
| 156, VII 3                   | Venus 4 fingers above    | 212.3              | -0.8              |
| 184, VIII 11?                | [Venus ...] above        | 214.0              | 1.3               |
| 192, VI 10                   | [Mars ...] above         | 215.6              | -0.6              |
| 201, VI 8                    | Venus 10 fingers below   | 213.9              | -2.7              |

**Table 3.2b: the longitude and latitude of planets on the dates of Normal Star Almanac predictions of passages by  $\beta$  and  $\delta$  Scorpii**

As with Table 3.1b, the longitudes and latitudes in this table were taken from JPL’s Horizons system, calculated for the planet’s position at midnight on the predicted date (or the date of closest approach when the date was broken). The column showing calculated planetary latitudes is particularly significant in this case: all the negative planetary latitudes are found for predictions involving  $\delta$  rather than  $\beta$  Scorpii. This confirms our expectations (as firmly as one can conclude from so little data) that  $\delta$  Scorpii was an alternate star to  $\beta$  Scorpii, used for the occasions when the planet had a particularly negative latitude as it moved through the constellation.

<sup>124</sup> Jones (2004), p. 485.

| Star name | LBAT no. of text | Babylonian Date |                 | Record  | Julian date  | Days (tithi) since vernal equinox | Days (tithi) since Sirius' rising |
|-----------|------------------|-----------------|-----------------|---|--------------|-----------------------------------|-----------------------------------|
| MÚL-MÚL   | *1118-9, Obv. 2  | Alm, SE 92      | Month I, 16?    | MÚL-MÚL x [...]   | -219, 5, 1   | 34                                |                                   |
|           | *1030a, Rev. 4   | NSA, SE 150     | Month VIII, 3   | KI KUR ŠAMÁŠ MÚL-MÚL <i>ina</i> ŠÚ<br>[ <i>ina</i> ] ŠÚ | -161, 10, 31 | 220                               |                                   |
|           | *1032, Rev. 1    | NSA, SE 156     | Month VIII, 10  | KI KUR ŠAMÁŠ MÚL<-MÚL> <i>ina</i><br>ŠÚ ŠÚ              | -155, 11, 1  | 221                               |                                   |
|           | 1154, Obv. 3     | Alm, SE 209     | Month II, 1     | MÚL-MÚL <i>ina</i> NIM IGI                              | -102, 5, 12  | 46                                |                                   |
|           | 1065, Obv. 6'    | NSA, SE 212     | Month II, 4     | MÚL-MÚL <i>ina</i> NIM IGI                              | -99, 5, 11   | 44                                |                                   |
|           | 1174, Obv. 2     | Alm, SE 236     | Month I, 29     | MÚL-MÚL <i>ina</i> NIM IGI                              | -75, 5, 12   | 46                                |                                   |
|           | 1174, Rev. 1     | Alm, SE 236     | Month VIII, 4   | MÚL-MÚL <i>ina</i> ZALÁG <i>ina</i> ŠÚ ŠÚ               | -75, 11, 10  | 231                               |                                   |
|           | 1177, Obv. 2     | Alm, SE 244     | Month I, 27     | MÚL-MÚL <i>ina</i> NIM [IGI ...]                        | -67, 5, 11   | 45                                |                                   |
|           |                  |                 |                 |   |              |                                   |                                   |
| (MÚL) BIR | *1030a, Obv. 16  | NSA, SE 150     | Month IV, 20?   | <i>ina</i> ZALÁG BIR <i>ina</i> KUR IGI                 | -161, 7, 22  | 117                               |                                   |
|           | *1030a, Obv. 23  | NSA, SE 150     | Month VI, 1     | <i>ina</i> ZALÁG MÚL BIR <i>ina</i> [KUR]<br>IGI        | -161, 8, 31  | 158                               |                                   |
|           | *1032, Obv. 3    | NSA, SE 156     | Month I, 26     | <i>ina</i> EN BIR <i>ina</i> ŠÚ ŠÚ                      | -155, 4, 23  | 25                                |                                   |
| ŠU-PA     | *1032, Obv. 18   | NSA, SE 156     | Month VI, 24    | <i>ina</i> ZALÁG ŠU-PA <i>ina</i> KUR IGI               | -155, 9, 16  | 174                               | 61                                |
| NUN.ki    | 1129, Obv. 5'    | Alm, SE 160     | Month VI, 2     | NUN.KI <i>ina</i> NIM IGI                               | -151, 9, 10  | 168                               | 56                                |
|           | 1130, Obv. 6'    | Alm, SE 162     | Month V, 24[+x] | MÚL NUN.KI <i>ina</i> NIM [...]                         | -149, 9, 11  | 169                               | 55                                |
|           | *1190, Obv. 8    | Alm, SE 301     | Month IV, 1     | MÚL NUN.'KI' ŠÚ   | -10, 7, 13   | 109                               |                                   |
|           | *1190, Obv. 11   | Alm, SE 301     | Month V, 20     | MÚL NUN.'KI x'  | -10, 8, 30   | 158                               | 45                                |

**Table 3.3: predictions of stars' rising and setting dates in the Normal Star Almanacs and the Almanacs.**

### 3.2 Unusual mentions of star visibilities in the predictive texts

In addition to the Normal Stars, a very small number of the predictive texts contain references to certain stars' heliacal rising and setting dates. Four different stars (other than Sirius<sup>125</sup>) are found in this context, in a total of ten different Normal Star Almanacs or Almanacs. Surprisingly, there is no evidence of the Babylonian astronomers observing these stars' risings and settings in the Diary records.

Table 3.3 summarises these records and converts the date of the prediction into the Julian calendar.<sup>126</sup> Also shown are the number of tithi between the vernal equinox and the prediction date for each record, and the number of tithi between Sirius' rising and the prediction date for certain records. The reasons behind this are explained below.

The Babylonian names for these stars/constellations have been identified with the following:

- MÚL-MÚL, "the stars" = the Pleiades. This is certain, because MÚL-MÚL as a name for the Pleiades (or at least for their brightest star,  $\eta$  Tauri) also occurs in the texts as a Normal Star. It is also in agreement with the scheme for the heliacal rising of the Pleiades found in Atypical Text B<sup>127</sup> - that the Pleiades should rise 1 month 15 tithi after the vernal equinox. This makes it immediately clear from the table that the rising date predicted for SE 92 is ~11 days too early, and that the setting date predicted for SE 236 is ~10 days too late. As Neugebauer & Sachs point out this is easy to do, given the 11-day difference between the lunar and solar year, by choosing one row too high or low in a column of calculated dates.

Unfortunately, none of the other stars in Table 3.3 agree with the dates in the second, unknown column of Atypical Text B. This column requires an event 16 days after the vernal equinox.

- (MÚL) BIR, "the kidney star". The identity of this star has not been confirmed, although Reiner & Pingree state that *Kalitum* = BIR "The Kidney" is a star in the constellation of NUN.KI "Eridu" (q.v.), possibly to be identified with  $\zeta$  Puppis.<sup>128</sup> Hunger & Pingree's list of stars mentions the Kidney, but unusually they do not speculate on its identity.<sup>129</sup> MÚL.APIN does not mention a Kidney Star; there is one reference to "the bright red star which stands in the kidney of the Stag: the Deleter",<sup>130</sup> but it is clear that this is a different star.

The predicted dates from the Normal Star Almanacs do not allow any of this speculation to be confirmed or disproved. In total they predict only three dates for MÚL BIR, and it is obvious that at least one of these dates is totally wrong. No star could have two different heliacal risings separated by less than two months, as the predictions for SE 150 suggest. Hunger believes that the earlier of the two dates should be disbelieved, as the tablet is rather damaged at this point.<sup>131</sup> It is quite possible that the earlier of the two rising dates could in fact be a broken prediction of *Sirius*' heliacal rising, which according to the Uruk

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<sup>125</sup> Sirius' rising and setting, as established in Chapter 2, were predicted as a matter of course in both the predictive texts and the Diaries.

<sup>126</sup> Using Parker & Dubberstein (1956) as usual.

<sup>127</sup> Neugebauer & Sachs (1967).

<sup>128</sup> Reiner & Pingree (1981), p. 4.

<sup>129</sup> Hunger & Pingree (1999), pp 271-277.

<sup>130</sup> Hunger & Pingree (1989), p. 28.

<sup>131</sup> H. Hunger, personal communication.

scheme should have taken place on day 16 of Month IV that year – very close to the date on the tablet.

- ŠU-PA = Boötes or principally Arcturus ( $\alpha$  Boötis), the third brightest star in the sky.<sup>132</sup> This is mentioned in MÚL.APIN as rising 60 days after Sirius, a number in agreement with the one preserved rising date from a Normal Star Almanac.<sup>133</sup>
- (MÚL) NUN.KI, “the star of Eridu”. The exact star is unknown, although the *constellation* of Eridu could be  $\alpha$ + Puppis<sup>134</sup> or “parts of Puppis and Vela”<sup>135</sup> according to Hunger & Pingree. Reiner & Pingree link NUN.KI to the constellation BIR (q.v.) and suggest  $\zeta$  Puppis (again) or the nearby Canopus ( $\alpha$  Carinae) for the principal star.<sup>136</sup> Canopus is surely a very plausible candidate for the star of Eridu; it is the second brightest star in the sky and yet does not seem to have any other Babylonian star designations linked to it. According to the Alcyone computer program,<sup>137</sup> Canopus would have been visible from Babylon and Uruk for the period between early September and early April.

In MÚL.APIN, the star of Eridu is said to rise 55 days after Sirius.<sup>138</sup> This is consistent with the dates in Table 3.3, and suggests that the rising date predicted for SE 301 is approximately 10 days too early. This could be another example of choosing the date in the wrong row of a table, or it could be that the recorded date should have been the 30<sup>th</sup> rather than the 20<sup>th</sup>. The date prediction is written at the end of a month, after predictions for the 27<sup>th</sup> and 28<sup>th</sup>, so a scribal error of 20 for 30 is a possibility.

Why do so few of the Almanacs and Normal Star Almanacs predict the dates of these stars? This is not just an example of a change of convention over the period, because the texts that record these predictions are dated to isolated years across a period of more than 200 years. A plausible explanation might lie in the fact that two of the texts – the Normal Star Almanacs for years SE 150 and SE 156 – definitely originate from the city of Uruk rather than Babylon. However, as previously established, many of the texts do not have good archaeological provenance, so we cannot be certain for each of the texts in Table 3.3 whether it is from Babylon or Uruk.

### ***3.3 Boundaries of the Zodiacal Signs***

The development of the zodiac in the fifth century B.C. provided Babylonian astronomers with a new means of specifying the position of the Moon or a planet. In analogy with the ‘ideal year’ of twelve 30-day months that appears in several earlier astronomical and astrological texts, the Babylonians divided the bands of the sky in which the sun, Moon and planets move into twelve segments, each one of which was subdivided into 30 parts.<sup>139</sup> Distances along these bands were measured by zodiacal signs and degrees within those signs.

As cited in the previous chapters, Huber showed that, for some of the zodiacal signs, the observed or predicted dates for when a planet will cross from one sign to another coincide

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<sup>132</sup> Reiner & Pingree (1981), p. 4.

<sup>133</sup> Hunger & Pingree (1989), p. 53.

<sup>134</sup> Hunger & Pingree (1989), p. 138.

<sup>135</sup> Hunger & Pingree (1999), p. 272.

<sup>136</sup> Reiner & Pingree (1981), p.8.

<sup>137</sup> Again, see §1.4.4 for a discussion of this tool.

<sup>138</sup> Hunger & Pingree (1989), p. 53.

<sup>139</sup> Steele (2007a).

with the date of the planet passing by a particular Normal Star.<sup>140</sup> These studies imply that the Babylonian zodiac was fixed sidereally (i.e., with respect to the stars), rather than tropically (i.e., with respect to the equinoxes) as in Greek astronomy. The discovery of two Babylonian catalogues of Normal Stars listing the positions of the stars in degrees within zodiacal signs supports this conclusion.<sup>141</sup>

The zodiac (as described in Chapter 1) appears in five principal contexts within Babylonian astronomy:

1. The zodiacal sign in which a visible planet is located during a month is reported in the summary at the end of an Astronomical Diary. In later Diaries, beginning in the last quarter of the third century B.C., this information is supplemented with the date on which the planet crossed from one zodiacal sign to the next.
2. The zodiacal sign in which a visible planet is predicted to be located at the beginning of a month and the date on which the planet is expected to cross from one zodiacal sign to the next is recorded in the Almanacs.
3. The zodiacal sign in which a planet is located on the day of its first and last visibilities and (usually) at its stations is recorded in the Astronomical Diaries, the Normal Star Almanacs, the Almanacs, the Goal-Year Texts and in several planetary compilations. In some cases the zodiacal sign is qualified with the adjective “beginning” or “end”.
4. The zodiacal sign in which the Moon is located during a lunar eclipse is occasionally recorded in the Astronomical Diaries, the Normal Star Almanacs, the Almanacs, the Goal-Year Texts and in some eclipse texts. In some cases the zodiacal sign is qualified with the adjective “beginning” or “end”.
5. In the texts of mathematical astronomy the positions of the sun, Moon and planets are given in degrees and fractions within zodiacal signs.

The following sections focus on analysing the preserved records in categories 1 to 4 of the list, with the aim of improving our understanding of how the Babylonian astronomers used the zodiac in practice. In particular, they investigate these questions: Were the zodiacal signs of equal length? What was meant by “beginning” or “end” of a zodiacal sign?

Records of the dates of a planet’s entry into a zodiacal sign appear in the summaries at the end of each monthly section of the Astronomical Diaries, beginning around the end of the third century BC. The records have a standard format: following the date is recorded the name of the planet, then the name of the zodiacal sign, and finally the technical term KUR. Sometimes this term is written with the addition of a phonetic complement KUR-*ád* and is to be read as a form of the Akkadian verb *kašadu* and literally means ‘to reach’ or ‘to arrive’. For example:

17 *dele-bat* PA KUR-*ád*  
 “The 17<sup>th</sup>, Venus reached Sagittarius”  
 (*ADART* Vol. III No. –124B, Obv. 18’)

The dates of sign entries given in the Diaries were determined by the Babylonian

<sup>140</sup> Huber (1958).

<sup>141</sup> Roughton, Steele & Walker (2004), Sachs (1952a).

astronomers from observed passages of the planets by Normal Stars, either directly in the case of Gemini, Cancer and Aquarius whose beginnings coincide with  $\zeta$  Tauri,  $\beta$  Geminorum and  $\delta$  Capricorni respectively, or indirectly for the other signs.

The Almanacs also predict dates of planets' zodiacal sign entries, with terminology identical to that found in the Astronomical Diaries. These dates were presumably determined in a similar fashion to those in the Astronomical Diaries, except that predicted passages of the planets by Normal Stars (which are recorded in the Normal Star Almanacs), rather than observed passages, would have been used.

For this investigation, a thorough search of all dated Astronomical Diaries and Almanacs was undertaken to compile exhaustive lists of dated records of planetary sign entries. In total 103 records from Astronomical Diaries and 235 records from Almanacs were found, dating between  $-212$  and  $-72$ , and  $-183$  and  $+74$  respectively. Appendix D provides details of these records.

The Julian date of each record was determined using the tables of Parker and Dubberstein,<sup>142</sup> supplemented by the calendrical data provided in *ADART* I-III. The tropical longitude of the planet on the date of the records was then determined using F. R. Stephenson and K. K. C. Yau's computer program based on the Breton ephemeris.<sup>143</sup> The superior planets' longitudes were uniformly calculated for a Terrestrial Time (TT) of 20.00 hrs (corresponding to a local time of about 8pm at Babylon during the first few centuries B.C.); for the inferior planets the longitude were calculated for TTs of either 20.00 hrs or 4.00 hrs, depending upon whether the planet was seen as an evening or a morning star.

Before commencing a detailed analysis of this material, it is worth noting that there can be a considerable variation in the longitudes of the planets on the dates when they are said to enter a particular zodiacal sign. For example, in the Diary *ADART* Vol. III No.  $-140A$  (which covers the first half of year SE 171) Mars reaches Cancer on the 19th of Month I, two days before Venus reaches the same sign on the 21st. However, Mars's tropical longitude on that date is  $86.04^\circ$  whereas Venus's longitude is only  $83.42^\circ$  at the time when it enters Cancer. Similarly, the Almanac for SE 355 predicts that both Mercury and Venus will enter Capricorn on the 29th of month IX, but the longitudes of the two planets on that day are  $269.06^\circ$  and  $267.86^\circ$  respectively. Evidently, it was not always easy for the Babylonian astronomers to determine the positions of the boundaries of the zodiacal signs.

A possible contribution to the uncertainty in variation of the longitude of a sign boundary may come from the latitude of the planet. As described in §1.3.5.2, Jones showed that the date on which a planet passed directly above or below a star was in some cases defined by the passage of the planet across an imaginary line between two nearby stars at approximately the same longitude. The latitude of the planet will therefore affect the longitude of its passage point. However, this effect is insufficient to account for many of the discrepancies in the position of the sign boundary.

### ***3.4 The Length of the Zodiacal Signs***

If the boundaries of the zodiacal signs used by the Babylonian astronomers during their observations were defined by passages of a planet by a star (either directly or by a certain distance in front of or behind that star), it is legitimate to ask whether the signs were all of

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<sup>142</sup> Parker & Dubberstein (1956).

<sup>143</sup> Breton, Simon & Laskar (1985), as discussed in §1.4.3.

equal length. Textual evidence from the star catalogues and other sources indicates that the Babylonian astronomers interpreted the signs as being of equal length,<sup>144</sup> but how did this translate into observational practice? The dates when a planet enters a zodiacal sign recorded in the Astronomical Diaries and the Almanacs may be used to investigate this question: if the dates of the entry of a planet into two consecutive signs (in other words, the dates when it enters and leaves a particular sign) are preserved, we can use modern ephemerides to calculate the celestial longitude of the planet on the two dates and therefore the length of that sign.

Unfortunately, although there are many preserved records of the dates of sign entries, only 9 times in the Astronomical Diaries and 51 times in the Almanacs is the following sign entry also preserved, providing dates when the planet both entered and left the sign. The data gathered from the two sources have been kept separate to ensure that if there is any early or late bias in the predicted dates of sign entries in the Almanacs, this will not affect the determination of the lengths of individual zodiacal signs. By only using pairs of data from the same tablet, any systematic error in the dates of predicted sign entries caused, for example, by making insufficient corrections to the whole-year Goal-Year periods that were used to determine planetary passages by Normal Stars,<sup>145</sup> will be eliminated by taking the difference between the positions of beginning and end of a sign.

Since there are many more data for the Almanacs than for the Astronomical Diaries let us first analyse the Almanacs. Table 3.4 lists details for the 51 cases where the dates of a planet entering and leaving a zodiacal are preserved. The overall mean sign length is  $30.31^\circ$  with a standard deviation of  $1.32^\circ$  in the data. Of course, whatever the length of the individual signs, the mean sign-length will always be close to  $30^\circ$ , but the small standard deviation implies that *all* the signs were close to  $30^\circ$  in length. It is worth noting that an error of up to a degree could be caused by the potential uncertainty of  $\pm 1$  day in our knowledge of the beginning of the Babylonian months.

It is possible that there is some small variation the mean lengths of the individual signs. For example, Aries and Cancer seem to be slightly over  $30^\circ$  in length, whereas Scorpio, Sagittarius and Capricorn all seem slightly under  $30^\circ$ . However, with such a small data sample we should be wary of drawing any conclusion from these discrepancies. Instead it seems most likely that all the zodiacal signs were in practice close to the ideal of  $30^\circ$  in length, but that any individual determination of the beginning or end of a sign could be off by up to a couple of degrees.

Table 3.5 shows the same analysis of the lengths of the zodiacal signs extracted from the Astronomical Diaries. The overall mean length of the zodiacal signs is  $29.85^\circ$  with a standard deviation of  $0.94^\circ$ . As with the Almanacs, the small standard deviation implies that the signs were all close to  $30^\circ$  in length. Unfortunately there are too few data to examine the zodiacal signs individually.

From this analysis of the dates when a planet enters and exits a zodiacal sign we can conclude that the zodiacal signs used in observational practice were intended to be, and closely were, of equal length. In any individual determination of when a planet entered a zodiacal sign, however, there could be a spread of up to a couple of degrees in where it was thought the sign began.

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<sup>144</sup> Steele (2007a).

<sup>145</sup> For details of these corrections, see Chapters 4 and 5; also Gray & Steele (2008).

| Zodiacal Sign | Planet  | Beginning of Sign |             | End of Sign |             | Sign Length | Mean  |
|---------------|---------|-------------------|-------------|-------------|-------------|-------------|-------|
|               |         | Date              | Trop. Long. | Date        | Trop. Long. |             |       |
| Aries         | Mars    | 183 X 15          | 353.32      | 183 XII 8   | 26.45       | 33.13       | 31.38 |
|               | Venus   | 183 XI 13         | 353.81      | 183 XII 16  | 26.85       | 33.04       |       |
|               | Mars    | 234 II 28         | 355.17      | 234 IV 17   | 26.27       | 31.10       |       |
|               | Venus   | 234 I 20          | 356.47      | 234 II 16   | 26.15       | 29.68       |       |
|               | Mars    | 236 I 26          | 356.38      | 236 III 9   | 26.34       | 29.96       |       |
| Taurus        | Mars    | 157 III 10        | 27.34       | 157 IV 23   | 54.78       | 27.44       | 29.62 |
|               | Venus   | 189 III 11        | 25.60       | 189 IV 10   | 55.97       | 30.37       |       |
|               | Mars    | 189 III 24        | 26.47       | 189 V 11    | 55.26       | 28.79       |       |
|               | Venus   | 234 II 16         | 26.15       | 234 III 12  | 57.41       | 31.26       |       |
|               | Mars    | 236 III 9         | 26.34       | 236 IV 25   | 56.60       | 30.26       |       |
| Gemini        | Mars    | 129 IV 7          | 58.36       | 129 V 28    | 90.84       | 32.48       | 30.48 |
|               | Venus   | 209 I 19          | 54.54       | 209 II 15   | 84.95       | 30.41       |       |
|               | Mars    | 236 IV 25         | 56.60       | 236 VI 29   | 86.37       | 29.77       |       |
|               | Venus   | 301 III 14        | 57.89       | 301 IV 8    | 86.62       | 28.73       |       |
|               | Venus   | 385 I 6           | 57.75       | 385 II 2    | 88.75       | 31.00       |       |
| Cancer        | Mercury | 178 III 13        | 82.97       | 178 IV 4    | 115.25      | 32.28       | 31.18 |
|               | Mars    | 178 V 3           | 83.26       | 178 VI 24   | 116.24      | 32.98       |       |
|               | Venus   | 190 II 2          | 85.29       | 190 II 28   | 115.08      | 29.79       |       |
|               | Venus   | 209 II 15         | 84.95       | 209 III 10  | 115.10      | 30.15       |       |
|               | Venus   | 236 II 26         | 83.93       | 236 III 21  | 114.60      | 30.67       |       |
|               | Venus   | 301 IV 8          | 86.62       | 301 V 4     | 117.12      | 30.50       |       |
|               | Venus   | 372 II 22         | 86.67       | 372 III 18  | 119.48      | 32.81       |       |
|               | Venus   | 385 II 2          | 88.75       | 385 II 28   | 119.01      | 30.26       |       |
| Leo           | Venus   | 178 V 15          | 111.46      | 178 VI 9    | 143.75      | 32.29       | 30.48 |
|               | Venus   | 236 III 21        | 114.60      | 236 IV 15   | 144.00      | 29.4        |       |
|               | Venus   | 301 V 4           | 117.12      | 301 V 28    | 146.87      | 29.75       |       |
| Virgo         | Mars    | 301 III 16        | 146.77      | 301 V 5     | 177.20      | 30.43       | 30.35 |
|               | Venus   | 355 VI 21         | 147.97      | 355 VII 16  | 178.24      | 30.27       |       |
| Libra         | Venus   | 201 V 4           | 175.91      | 201 VI 1    | 206.30      | 30.39       | 30.14 |
|               | Venus   | 355 VII 16        | 178.24      | 355 VIII 11 | 207.93      | 29.69       |       |
|               | Venus   | 372 V 9           | 177.01      | 372 VI 5    | 207.34      | 30.33       |       |
| Scorpio       | Venus   | 201 VI 1          | 206.30      | 201 VII 1   | 236.12      | 29.82       | 29.45 |
|               | Venus   | 236 VI 8          | 207.13      | 236 VII 2   | 235.73      | 28.60       |       |
|               | Venus   | 355 VIII 11       | 207.93      | 355 IX 5    | 237.87      | 29.94       |       |
| Sagittarius   | Venus   | 236 VII 2         | 235.73      | 236 VII 28  | 265.86      | 30.13       | 29.53 |
|               | Venus   | 355 IX 5          | 237.87      | 355 IX 29   | 267.86      | 29.99       |       |
|               | Mercury | 355 IX 8          | 240.88      | 355 IX 29   | 269.06      | 28.18       |       |
|               | Venus   | 372 VII 3         | 237.54      | 372 VIII 3  | 267.35      | 29.81       |       |
| Capricorn     | Venus   | 183 VIII 25       | 264.31      | 183 IX 21   | 293.76      | 29.45       | 29.35 |
|               | Mercury | 209 X 9           | 263.96      | 209 XI 1    | 293.26      | 29.30       |       |
|               | Venus   | 236 VII 28        | 265.86      | 236 VIII 26 | 294.98      | 29.12       |       |
|               | Mars    | 305 VIII 8        | 266.20      | 305 IX 16   | 295.74      | 29.54       |       |
| Aquarius      | Venus   | 183 IX 21         | 293.76      | 183 X 15    | 322.65      | 28.89       | 30.57 |
|               | Mars    | 209 IX 18         | 294.05      | 209 X 28    | 325.27      | 31.22       |       |
|               | Venus   | 209 XI 28         | 291.45      | 209 XII 29  | 324.72      | 33.27       |       |
|               | Venus   | 236 VIII 26       | 294.98      | 236 X 5     | 324.30      | 29.32       |       |
|               | Mars    | 305 IX 16         | 295.74      | 305 X 26    | 325.90      | 30.16       |       |



| Zodiacal Sign | Planet | Beginning of Sign |             | End of Sign |             | Sign Length | Mean  |
|---------------|--------|-------------------|-------------|-------------|-------------|-------------|-------|
|               |        | Date              | Trop. Long. | Date        | Trop. Long. |             |       |
| Pisces        | Mars   | 183 VIII 27       | 323.91      | 183 X 15    | 353.32      | 29.41       | 29.90 |
|               | Venus  | 183 X 15          | 322.65      | 183 XI 13   | 353.81      | 31.16       |       |
|               | Mars   | 234 I 17          | 326.17      | 234 II 28   | 355.17      | 29.00       |       |
|               | Mars   | 305 X 26          | 325.9       | 305 XII 7   | 355.94      | 30.04       |       |

**Table 3.4: The length of zodiacal signs taken from the Almanacs.**

| Zodiacal Sign | Planet | Beginning of Sign |             | End of Sign |             | Sign Length |
|---------------|--------|-------------------|-------------|-------------|-------------|-------------|
|               |        | Date              | Trop. Long. | Date        | Trop. Long. |             |
| Taurus        | Mars   | 174 II 30         | 25.37       | 174 IV 16   | 56.19       | 30.82       |
|               | Venus  | 234 II 16         | 26.15       | 234 III 12  | 57.41       | 31.26       |
| Gemini        | Venus  | 206 I 2           | 55.70       | 206 I 27    | 85.17       | 29.47       |
|               | Venus  | 234 III 12        | 57.41       | 234 IV 7    | 86.63       | 29.23       |
| Cancer        | Venus  | 206 I 27          | 85.17       | 206 II 24   | 114.81      | 29.64       |
|               | Venus  | 234 IV 7          | 86.63       | 234 V 2     | 117.42      | 30.79       |
| Virgo         | Venus  | 179 VII 1         | 145.83      | 179 VII 28  | 175.02      | 29.19       |
| Sagittarius   | Venus  | 187 IX 17         | 237.14      | 187 X 10    | 265.51      | 28.36       |
| Pisces        | Venus  | 186 I 2           | 322.30      | 186 I 29    | 352.21      | 29.91       |

**Table 3.5: The length of zodiacal signs taken from the Diaries.**

### 3.5 The “Beginning” and “End” of a Zodiacal Sign

The earliest Astronomical Diaries of the sixth and seventh centuries B.C. include observations of the planets’ Greek letter phenomena recorded relative to zodiacal constellations. In these early texts the planet may be said to be, for example, “behind” (*ár*) or “in front of” (*ina* IGI) a constellation. After the development of the zodiac in the fifth century B.C., observations and predictions of planetary phenomena in all of the main non-mathematical text types are said to occur “in” (*ina*) a zodiacal sign.<sup>146</sup> Most of these records simply state that the event happened, for example, “in Libra”, but a subset of the records — up to a third — are more specific with the position given in the form of “in the beginning (SAG) / end (TIL) of Libra”.

The same terminology is used in all of the observational or predictive texts for reporting positions in the beginning or end of a zodiacal sign. The following examples demonstrate the standard terminology:

‘GAN’ 21 ‘GENNA *ina* MÁŠ ŠÚ’ ZÍZ 2 ‘GENNA’ *ina* TIL ‘MÁŠ  
 IGI’  
 “Month IX, the 21st, Saturn’s last appearance in Capricorn. Month XI,  
 the 2nd, Saturn’s first appearance in the end of Capricorn.”  
 (ADART Vol. VI, No. 8, Obv. 10’ (Goal-Year Text for S.E. 94))

<sup>146</sup> Rochberg-Halton (1991), pp. 109-111.

22 MÚL-BABBAR *ina* TIL *zib*<sup>ME</sup> UŠ  
 “The 22nd, Jupiter stationary in the end of Pisces.”  
 (LBAT 1195, Obv. 8 (Almanac for S.E. 305))

Almost all of the records containing zodiacal signs are observations or predictions of the planets’ Greek letter phenomena. In practice this means that most of the data relate to the first and last visibilities of the planets, particularly those of Mercury. In part this is because Mercury’s appearances and disappearances occur significantly more frequently than any other planetary phenomenon, and in part because records of stationary points and acronychal risings do not always indicate the planet’s location. As mentioned in the previous sections, observational records of stationary points quite often give the planet’s position relative to a Normal Star instead of a zodiacal sign, and only one example was found where the zodiacal sign of a planet’s acronychal rising was observed or predicted:

10 AN *ina* TIL MÚL.A *ana* ME-A  
 “The 10th, Mars’s acronychal rising in the end of Leo.”  
 (MLC 1860, rev. 15 (Normal Star Almanac for S.E. 82))

It is also necessary to take into account the fact, as discussed in Chapter 2, that the Diaries record these observations in both the main body of the monthly section and in the end of month summaries. For example, in Diary No. –168A we read in the main part of the entry for Month V:

24 *dele-bat ina* ŠÚ *ina* TIL ABSIN IGI 8,30 *na-su in* 22 IGI  
 “The 24th, Venus’s first appearance in the west in the end of Virgo;  
 sunset to setting of Venus: 8°30’; (ideal) first appearance on the 22nd.”  
 (ADART Vol. II No. –168A, Obv. 10)

However, at the end of the month we find:

*in* 22 *dele-bat ina* ŠÚ *ina* ABSIN IGI  
 “Around the 22nd, Venus’s first appearance in the west in Virgo”  
 (ADART Vol. II No. –168A, Obv. 13)

This common practice of “ideal” dates in the later Diaries was discussed in detail in the previous chapter; here the important point to remember is that the observations recorded in the main text for the month and those in the summaries do not always match. Occasionally, the Babylonian astronomers reported that the planet was located in a different sign of the zodiac on the ideal and observed dates. For example, a first appearance of Mercury was observed in the beginning of Gemini on the 30th of Month I in S.E. 193 but should apparently have been seen three days earlier:

30 GU4-UD *ina* ŠÚ [*ina* SA]G MAŠ-MAŠ 2/3 KÙŠ *ina* IGI GENNA ‘1’  
 ½ KÙŠ *ana* SI NIM IGI K[UR<sup>2</sup> NIM-*a*<sup>2</sup> nn *na-su in*<sup>2</sup> 27 *ina* TIL MÚL-  
 MÚ]L IGI  
 “The 30th, Mercury’s first appearance in the west [in the beginn]ing of  
 Gemini, 2/3 cubit in front of Saturn, 1½ cubits high to the north; it was  
 br[ight<sup>2</sup> and high<sup>2</sup>, sunset to setting of Mercury: nn°;] (ideal) first  
 appearance [on the 27th in the end of Taur]us.”  
 (ADART Vol. III No. –118A, Obv. 15)

The ideal date in the above record has presumably been restored from the end of month

summary, in which the ideal date of the first visibility is recorded and Mercury’s position on this ideal date is recorded as the *end* of Taurus:

*in 27 GU4-UD ina ŠÚ ina TIL MÚL-MÚL IGI*  
 “Around the 27th, Mercury’s first appearance in the west in the end of  
 Taurus.”  
 (*ADART* Vol. III No. –118A, Obv. 18)

We can conclude from examples such as this that even if we cannot be sure whether the date given for a record was observed or ideal, we can expect that the planets’ beginning / end / otherwise status is correct for that date.

To understand when the terms “beginning” or “end” were applied to the non-mathematical observations and predictions, an exhaustive database was compiled of records of this type which refer to a planet’s location in zodiacal sign at the time of a Greek-letter phenomenon. The full details of the records in the database can be found in Appendix E. The database contains all such entries for which the Babylonian year, month and day are known; this included ones where the date is specified as “around the (day number)”, but not those for which the day number is missing or partially broken.

For each record the Babylonian date has been converted into a Julian date using Parker and Dubberstein’s tables and the longitude of the planet in question on each date was then determined using the Bretagnon ephemeris. A TT of 20.00 for evening observations and 04.00 for morning observations of inferior planets was assumed, and a local time of 00.00 for all observations of superior planets.

Finally, the tropical longitudes needed to be corrected to account for precession. Huber discovered that the Babylonian zodiac was aligned with certain stars, implying that the zodiac will gradually shift relative to a tropical frame of reference as a result of precession.<sup>147</sup> Huber estimated that the zero-point of the Babylonian zodiac in –100 was at a tropical longitude of 4°22′. The rate of precession is about 0.013825° per year and, by adjusting for precession, we therefore find that Huber’s result corresponds to a zero-point at about 3.08° in year 0. Therefore, the tropical longitudes were converted to Babylonian sidereal longitudes using the following equation:

$$\lambda_B = \lambda_T + 3.08 + 0.013825y$$

where  $\lambda_B$  is the Babylonian longitude,  $\lambda_T$  is the tropical longitude and  $y$  is the astronomical year number. This equation was most recently analysed by Gray & Steele, who recommend continued use of Huber’s equation.<sup>148</sup>

In 16 of the database’s records, the calculated longitude of the planet on the date given in the text indicated that it was a considerable distance away from the zodiacal sign recorded in the text – usually more than 30°, i.e. the planet was not even in the neighbouring zodiacal sign – which are clearly errors. The discrepancies could be due to a scribal error of writing down the wrong sign; occasional copying errors are inevitable when considering a large data set such as this, where records have been copied and recopied from other texts (such as data in Goal-Year Texts having been copied from Astronomical Diaries). These 16 records have been omitted in the subsequent investigations.

<sup>147</sup> Huber (1958).

<sup>148</sup> Steele & Gray (2007), pp. 448–449.

However, there is a clear difference between these omitted cases and the few records where a planet's longitude was only a small number of degrees into the adjacent zodiacal sign. The latter records have been included unless there is further evidence to treat them as an error such as the case of Mars's first appearance recorded in the Astronomical Diary No. –144 for Month VI:

*in 13 AN ina ABSIN IGI in 10+x [...] AN ABSIN KUR*  
 “Around the 13th, Mars's first appearance in Virgo; around the 10[+xth,  
 ...] Mars reached Virgo”  
 (*ADART* Vol. III No. –144, Obv. 13)

On this date Mars's longitude was in fact about 146°, i.e. 4° before the end of Leo, at the time of its first appearance. This record has therefore not been included in the analysis, as it seems more likely that this is a copying error rather than the Babylonian astronomers intending Mars's first appearance to be in a zodiacal sign it only reaches several days later. Records in the Diaries are virtually always listed chronologically, and so Mars's entry into Virgo must have occurred after the 13<sup>th</sup>.

Note that texts which contain observations of planets in zodiacal signs but which do *not* include at least one taking place in the “beginning” or “end” of a sign have not been included in the database. This is because it is evident from the records that the practice of mentioning the beginning/end of a sign was not always followed. It is impossible to distinguish between a text that does not mention beginning/end by choice (which it would not be useful to include) and one that does not mention beginning/end because nothing happened in the beginning/end of a sign at that time, or because a relevant portion of the text has broken away.

The breakdown of remaining records used for the analysis is:

| Text Type            | Total Records | “Beginning” | “End” |
|----------------------|---------------|-------------|-------|
| Diaries              | 247           | 39          | 42    |
| Goal-Year Texts      | 214           | 24          | 27    |
| Normal Star Almanacs | 135           | 17          | 17    |
| Almanacs             | 129           | 11          | 15    |

For each corrected planetary longitude, the longitude of the beginning of its zodiacal sign was subtracted (0° for Aries, 30° for Taurus and so on) to give a measure of how far into the zodiacal sign the planet was at that time. In other words, any points for which this value was above 30° or below 0° were in fact in the neighbouring zodiacal sign at the time of observation. This data is summarized in Figures 3.1a (Astronomical Diaries), 3.1b (Goal-Year Texts), 3.1c (Normal Star Almanacs), and 3.1d (Almanacs). The x-axis shows the points in chronological order according to the date of the observation or prediction, spreading the data equidistantly along the axis rather than representing any particular time scale. This is for ease of reading, as a linear timescale would result in a more confusing figure, with the data points for any particular year being shown too close together for clarity and long empty gaps along the time axis.

The figures show that, in general, “beginning” observations fall mostly between 0° and 5° of a zodiacal sign, and “end” observations fall mostly between 25° and 30°. This result is consistent across each type of text, allowing us to suggest the conclusion that the Babylonian astronomers considered the “beginning” and “end” of a zodiacal sign to be approximately the first and last 5° respectively. In addition the figures show that this was

not a case of the regions' being exclusively "beginning", "middle" or "end" of a sign, as 'unclassified' (those where no qualifying adjective is used to the zodiacal sign) records can still refer to the first or last 5° of a sign.

The same results are represented in Figures 3.2a-d, which summarise the frequency of the three types of records ("beginning", unclassified or "end") across the zodiacal signs. The figures make it immediately clear that, as with the previous figures, "beginning" records are extremely common between 0° and 5°, and "end" records are extremely common between 25° and 30°. Unclassified records occur across the entire zodiacal sign at roughly the same frequency, with a slight trend towards the middle of the sign as we might expect.

The data are also summarized in Table 3.6, which shows the mean distances from the zodiacal sign boundary for each "beginning" and "end" record, and the standard deviations. For this table the longitude difference between the planet and the *nearest* zodiacal boundary was calculated; i.e. the longitude 0° into the zodiacal sign for "beginning" records, and the longitude 30° into the zodiacal sign for end records.

For each text, values are given for three different subsets of the data: all of the planets together; Mercury alone; and the four planets other than Mercury. The number of data points being considered in each case is also given. Mercury is analysed separately because its motion is particularly fast, making its records more prone to errors. For the other planets, the number of data points is too small for individual analysis to be worthwhile, particularly in the case of the small datasets of the Normal Star Almanacs and Almanacs.

The tables show an overall mean distance of between 3° and 4° into zodiacal signs for the beginning and end data, with a standard deviation of between 2° and 3° across the various types of text. This lends considerable further support to the suggestion that the "beginning" and "end" of a zodiacal sign were intended to correspond to about the first and last 5° of the sign. There is no evidence that the "beginning" and "end" regions were intended to be of different length.

As we would expect, the mean distance of Mercury into a sign and its standard deviation are both somewhat larger than for the other planets. Mercury can move through the 5° "beginning" or "end" region in only two or three days, and so an uncertainty of one day in the date of the record will have a noticeable effect on its position.

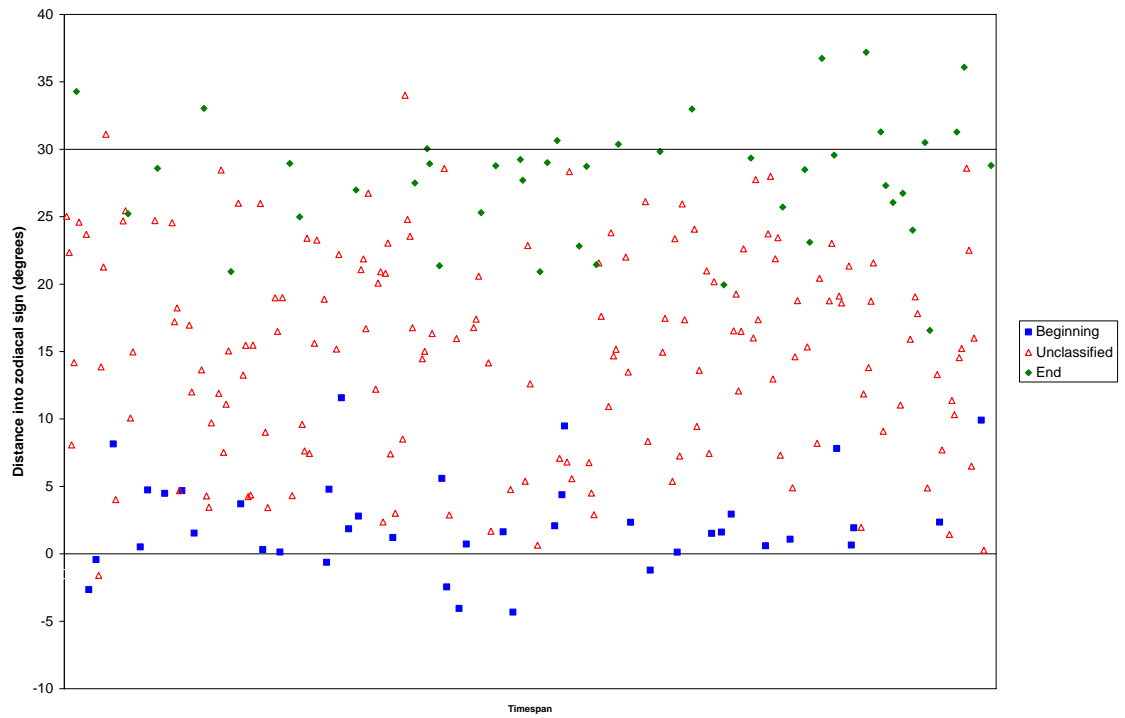


Figure 3.1a: The planet’s distance into the zodiacal sign at the point of each dated Greek-letter phenomenon recorded in the *Astronomical Diaries*. The data are divided into three categories: records which specify the “beginning” of the zodiacal sign, records which specify the “end” of the zodiacal sign, and records which specify neither.

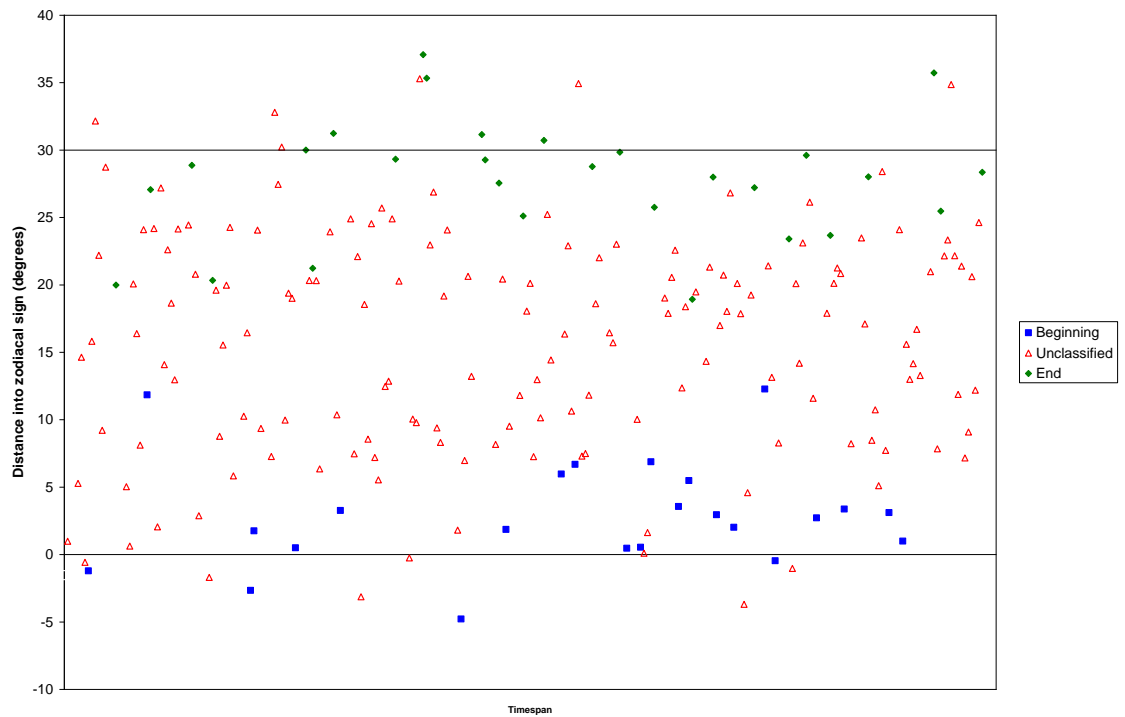


Figure 3.1b: As Figure 3.1a, for the *Goal-Year Texts*’ records

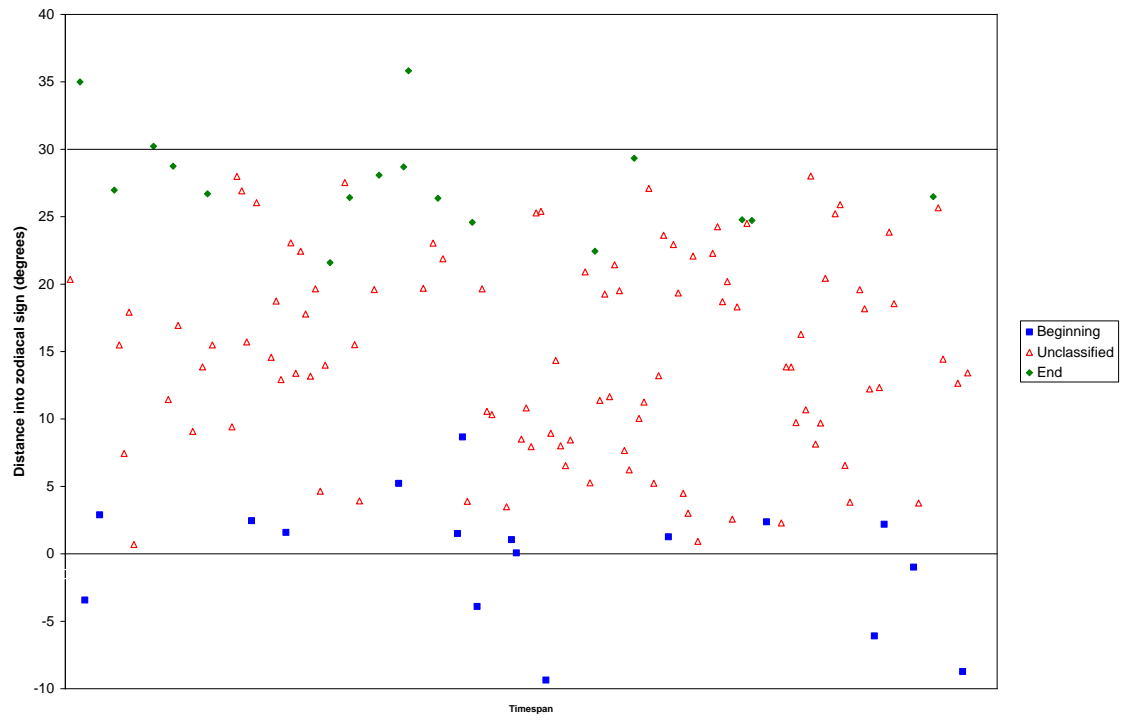


Figure 3.1c: As Figure 3.1a, for the Normal Star Almanacs' records

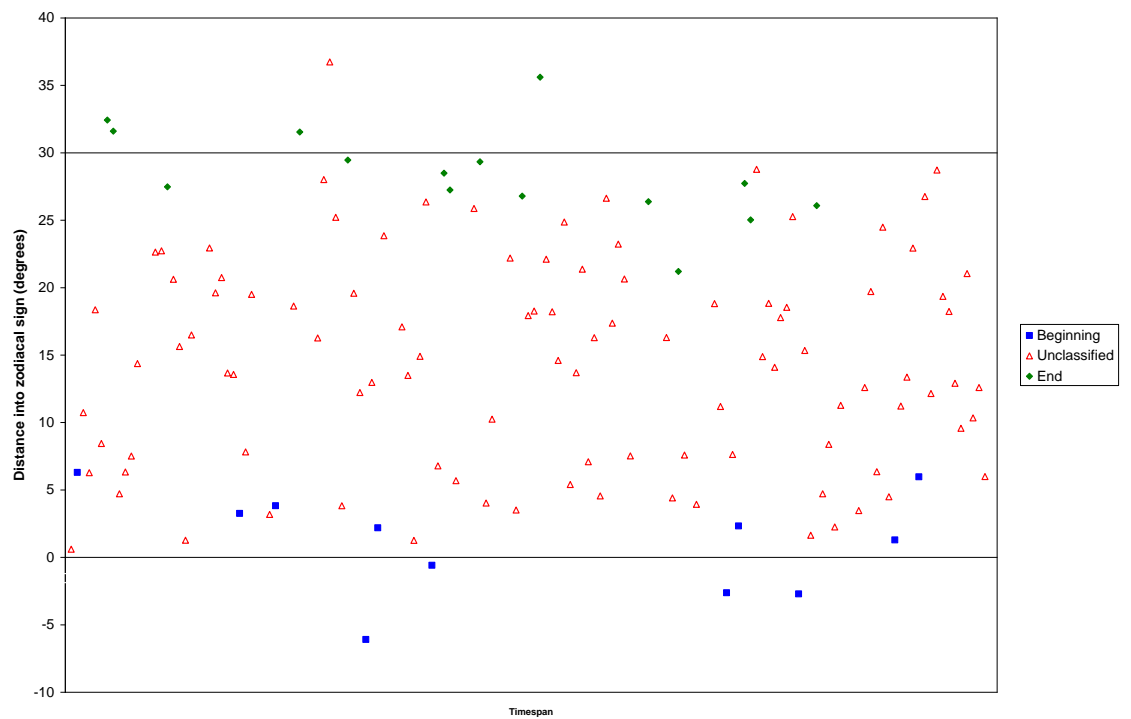


Figure 3.1d: As Figure 3.1a, for the Almanacs' records

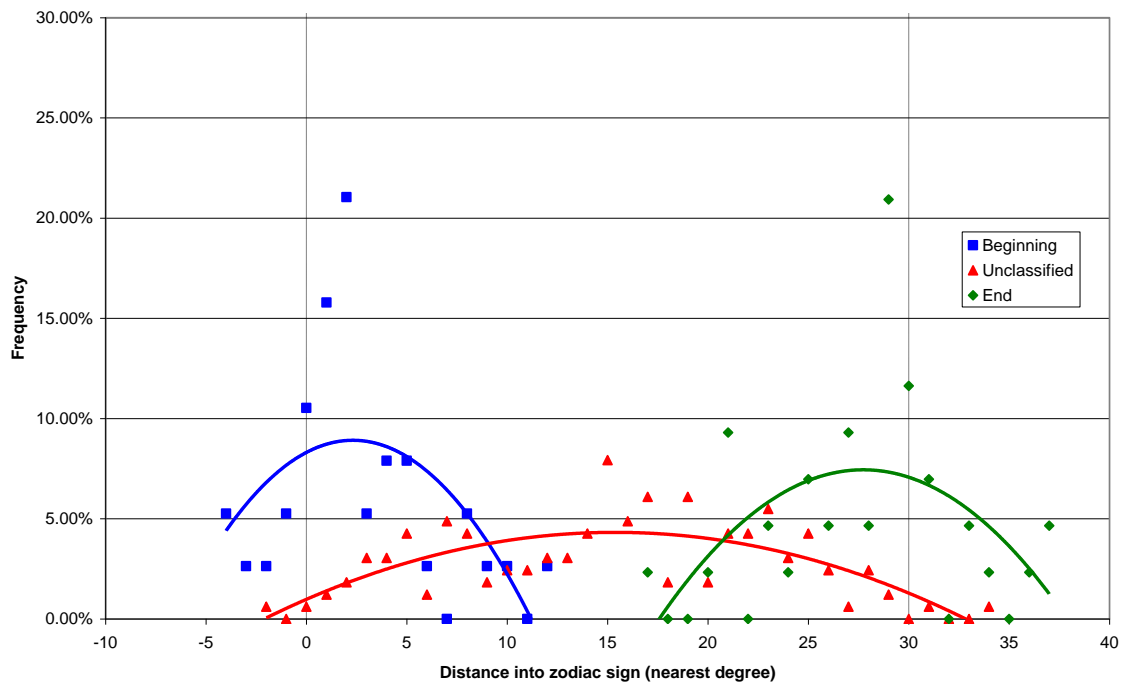


Figure 3.2a: the frequency of beginning/unclassified/end records across the zodiacal signs for observations from the Astronomical Diaries.

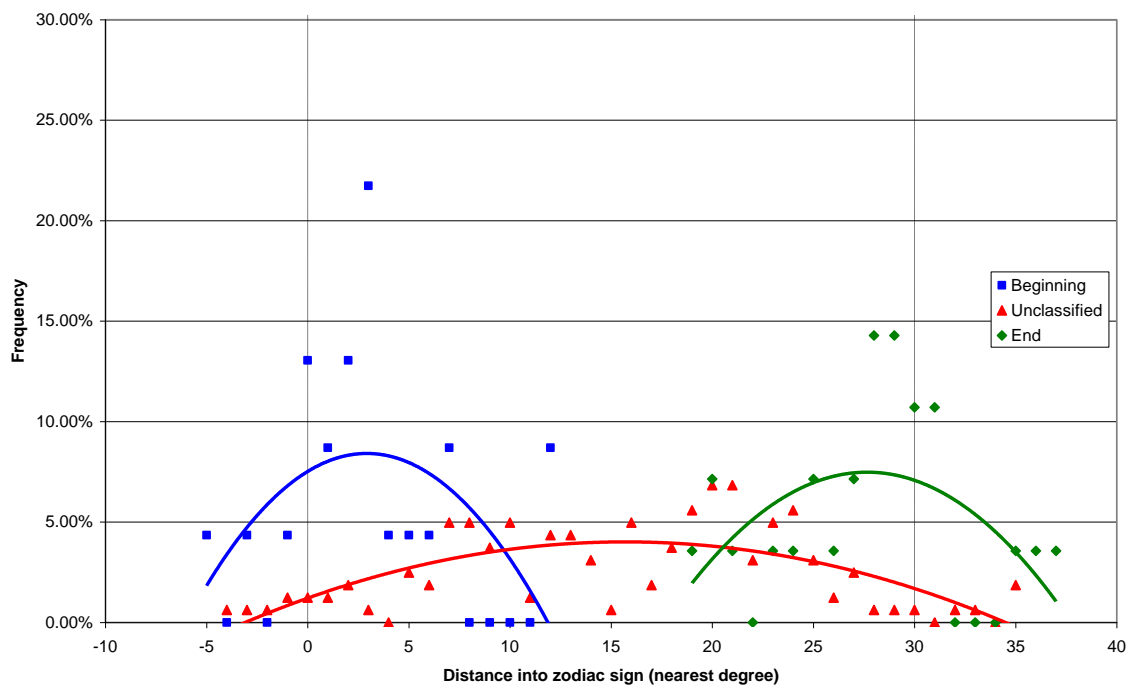


Figure 3.2b: as Figure 3.2a, for the Goal-Year 'Texts' observations



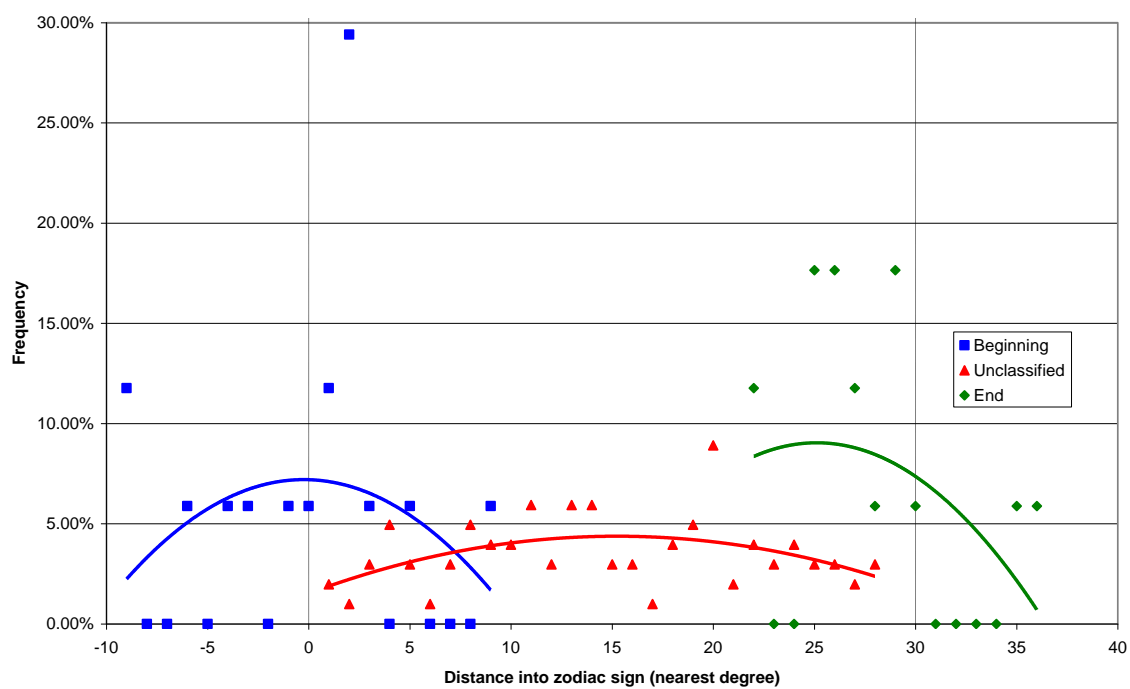


Figure 3.2c: as Figure 3.2a, for the Normal Star Almanacs' predictions

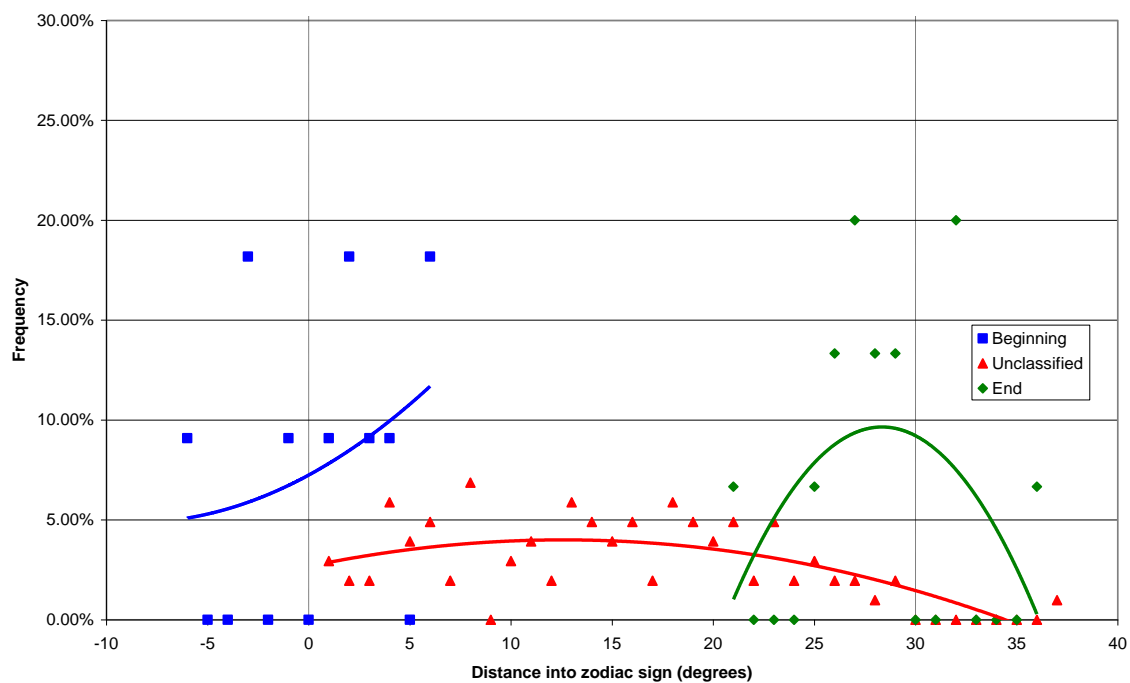


Figure 3.2d: as Figure 3.2a, for the Almanacs' predictions

| Text type            | Planet        | Number of records | All ‘beginning’ and ‘end’ records |                        | All ‘beginning’ records |                        | All ‘end’ records |                        |
|----------------------|---------------|-------------------|-----------------------------------|------------------------|-------------------------|------------------------|-------------------|------------------------|
|                      |               |                   | Mean distance (°)                 | Standard deviation (°) | Mean distance (°)       | Standard deviation (°) | Mean distance (°) | Standard deviation (°) |
| Astronomical Diaries | All planets   | 81                | 3.556                             | 3.062                  | 3.161                   | 2.723                  | 3.847             | 3.260                  |
|                      | Mercury       | 39                | 4.502                             | 3.628                  | 4.007                   | 3.532                  | 4.846             | 3.733                  |
|                      | Other planets | 42                | 2.678                             | 2.109                  | 2.758                   | 2.094                  | 2.698             | 2.181                  |
| Goal-Year Texts      | All planets   | 51                | 3.629                             | 3.263                  | 3.597                   | 3.253                  | 3.657             | 3.331                  |
|                      | Mercury       | 26                | 4.043                             | 3.553                  | 3.811                   | 3.360                  | 4.227             | 3.806                  |
|                      | Other planets | 25                | 3.077                             | 2.938                  | 3.382                   | 3.277                  | 2.773             | 2.666                  |
| Normal Star Almanacs | All planets   | 34                | 3.735                             | 2.624                  | 3.634                   | 2.951                  | 3.836             | 2.338                  |
|                      | Mercury       | 11                | 5.429                             | 2.615                  | 5.726                   | 3.026                  | 5.071             | 2.315                  |
|                      | Other planets | 23                | 2.925                             | 2.258                  | 2.493                   | 2.301                  | 3.322             | 2.241                  |
| Almanacs             | All planets   | 26                | 3.342                             | 2.090                  | 3.717                   | 2.053                  | 3.066             | 2.145                  |
|                      | Mercury       | 15                | 3.284                             | 2.544                  | 3.617                   | 2.339                  | 2.993             | 2.836                  |
|                      | Other planets | 11                | 3.420                             | 1.362                  | 3.891                   | 1.744                  | 3.150             | 1.157                  |

**Table 3.6: Analysis of records of planetary positions in the ‘beginning’ or ‘end’ of a zodiacal sign**

Lastly, there are a small number of lunar eclipse records that give the zodiacal sign in which the observed or predicted eclipse could be seen. (As previously established, the majority of eclipse records that give a position use the Normal Stars as reference points.) The few eclipse records which mention a position relative to the beginning or end of a zodiacal sign are summarized in Table 3.7. There are too few to analyse statistically but the corrected longitude of the start and end of each eclipse are in general agreement with the above estimate of the “beginning” or “end” region of the zodiacal signs.

| Date        | Eclipse location                       | Corrected longitude (°) |                |
|-------------|--|-------------------------|----------------|
|             |  | Start of eclipse        | End of eclipse |
| –178 Jul 24 | Predicted in the beginning of Aquarius | 301.30                  | 302.76         |
| –170 Aug 23 | Observed in the end of Aquarius        | 330.99                  | 333.15         |
| –105 Aug 25 | Observed in the beginning of Pisces    | 330.68                  | 332.38         |
| –98 Apr 11  | Observed in the end of Libra           | 202.16                  | 204.34         |

**Table 3.7: Details of lunar eclipse records which give the position of the Moon in the “beginning” or “end” of a zodiacal sign**

## *Chapter 4*

# **The effectiveness of the Goal-Year type planetary periods**

### *4.1 Introduction*

One question relating to Goal-Year astronomy which has raised relatively little discussion is why the Babylonian astronomers chose the particular planetary periods which were used in the Goal-Year Texts. This chapter will analyse the various planetary periods found in Late Babylonian astronomical texts to assess how effective they are compared with each other (and evaluate how exactly we can define “effective” in this context), and hopefully reach some understanding of why the compilers of the Seleucid Era texts settled on the particular Goal-Year periods that they chose.

It may be helpful to think of the recurrence relations for the planets in terms of their mean synodic periods. It is clear that periods across which planetary events recur closely will be found at the points where a planet’s mean synodic period in days is very close to an integer number of mean solar years. For example, 46 mean solar years = 144.99 synodic periods of Mercury, suggesting that events for Mercury will recur closely after 46 years; similarly, 8 mean solar years = 5.005 synodic periods of Venus.<sup>149</sup> This provides an important starting-point for considering which planetary periods would in theory work well. However, one must bear in mind that the recurrence relations calculated in this way are relative to the mean solar year of  $\sim 365.24$  days. While the length of the mean Babylonian year is of course extremely close to this number, any particular Babylonian year can only be a whole number of lunar months and therefore will be  $\sim 354$  or  $\sim 384$  days. The effect of the Babylonian year’s variable length is analysed in Chapter 6.

### *4.2 The procedure texts*

First we must examine where the planetary periods are found. The main source for these is, of course, the Goal-Year Texts, in which the same planetary periods were consistently used across 200 years. However, there are several other texts which refer to various other planetary periods being used to make Goal-Year type empirical predictions, particularly in the pre-Seleucid period.

For conciseness in this thesis, I refer to the texts from which the planetary periods are taken as “procedure texts”. Note that I am only considering the texts which refer to periods for planetary events, rather than texts with ACT-type methods for calculating successive phenomena of a planet, say, or daily longitude/latitude changes.<sup>150</sup>

It is also important to note that, unlike the procedure texts in mathematical astronomy, the texts described here are *not* generally linked in any way and do not form any kind of coherent series. Indeed, most of them have been described by modern scholars as “unusual” or “atypical”, for various reasons. The texts come from different points across the entire Late Babylonian Period, originate from different cities, and appear to have been

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<sup>149</sup> with thanks to F. R. Stephenson for pointing these synodic periods out to me.

<sup>150</sup> See, for example, Atypical Text F in Neugebauer & Sachs (1967), and the texts discussed in Steele (2005), although tablet BM 40661 in the latter reference does also state Jupiter’s 12-year period.

written for a variety of uses both astronomical and astrological. The only aspect that they are certain to have in common is that they contain some reference (or apparent reference) to a number of years over which a planet's motion or position will recur. The following sections will introduce the texts individually, in roughly chronological order, to give an impression of their contents, apparent uses, and approximate dates.

#### 4.2.1 The Goal-Year Texts

As described in Chapter 2, the Goal-Year Texts contain excerpts from Astronomical Diaries for particular years, with specific periods in mind. As a reminder, the planetary periods used in the creation of these texts are repeated below, along with the number of mean synodic periods covered by this period of years (calculated by F R. Stephenson):

|                                  |          |                         |
|----------------------------------|----------|-------------------------|
| Mercury's events                 | 46 years | 144.99 synodic periods  |
| Venus' events                    | 8 years  | 5.005 synodic periods   |
| Mars' Greek-letter phenomena     | 79 years | 36.995 synodic periods  |
| Mars' Normal Star passages       | 47 years | 22.01 synodic periods   |
| Jupiter's Greek-letter phenomena | 71 years | 65.01 synodic periods   |
| Jupiter's Normal Star passages   | 83 years | 76.0006 synodic periods |
| Saturn's events                  | 59 years | 56.995 synodic periods  |

#### 4.2.2 BM 92685 (DT 78)

This is an unusual astrological text, which contains omen clauses written entirely in numbers. Gadd's study of this text includes a transliteration of the last 11 lines of the tablet (Rev. lines 56' to 66'), which mention the planets and a list of years which may refer to planetary periods.<sup>151</sup> Lines 56' to 60' each mention one of the planets, in the conventional order found in the Goal-Year Texts (i.e. Jupiter, Venus, Mercury, Saturn, Mars). Lines 61' to 66' each contain a reference to a specific number of years (along with other, less-understood remarks) in the following order: 71, 60, 59, 8, 15, 12.

These years are not linked with any specific planet in the text but, as Gadd points out, 71, 59 and 8 years are surely references to the Goal-Year periods for, respectively, Jupiter, Saturn, and Venus.<sup>152</sup> He speculates on which planets the other periods may refer to, as well as querying why the above sequence of years contains six entries when only the five standard planets are mentioned in the text, and why the sequence of years visibly does *not* refer to the planets in the conventional order. However, he does not draw any firm conclusions.

There has been more recent speculation on what this sequence of years refers to. Brown believes that the sequence refers to planetary periods for, respectively, Jupiter (71 years); Mercury (60 years); Saturn (59 years); Venus (8 years); Mars (15 years); and Jupiter again (12 years).<sup>153</sup>

An alternative suggestion has recently been proposed by Britton, who interprets the numbers as planetary periods for, respectively, Jupiter (71 years); the Sun (interpreting the second numeral as "1" rather than Gadd's "60"); Jupiter [sic] (8 years; clearly Venus is intended); Mars (15 years); and Mercury (Britton suggesting that "12" in the text is a scribal

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<sup>151</sup> Gadd (1967).

<sup>152</sup> Gadd (1967), p.61-62. See also Hunger (1969).

<sup>153</sup> Brown (2000), p. 194.

error for Mercury's elsewhere-attested period of 13 years).<sup>154</sup>

In other words, the three possible interpretations agree on the purpose of the numbers 71, 59, 8 and 15, and disagree on the numbers 60 (or 1) and 12 (or 13). Jupiter's 12-year period and Mercury's 13-year period are attested in other texts, making either interpretation equally plausible. In either case, it is interesting that DT 78 also appears to contain the only reference to a 15-year period for Mars and, if the former of the two interpretations is correct, it also represents the only reference to a 60-year period for Mercury. (See the summary in Table 4.2 later in this chapter.)

Gadd dates DT 78 securely to the late 7<sup>th</sup> century BC, based on a note on the tablet that it belonged to a group of tablets compiled for the son of King Ashurbanipal.<sup>155</sup> Brown interprets this note as referring to the King himself rather than his son, but otherwise agrees with Gadd by suggesting a date in "the period before 612 BC".<sup>156</sup> If these dates are correct, then the tablet therefore represents one of the earliest references to planetary periods. Of particular interest is the implication that at least some of the Goal-Year periods were known of so early in the period, roughly 400 years before the earliest extant Goal-Year Texts.

#### 4.2.3 BM 45728

BM 45728 is a true procedure text, containing periods of recurrence (expressed in terms of number of years plus a date correction) for the Moon, Venus, Mercury, Mars, Saturn and Sirius. The text was described (and copied) in SSB I,<sup>157</sup> and more recently by Britton, who translates the text as well as summarising the periods and their corrections.<sup>158</sup> The lack of a period for Jupiter is puzzling, but as Britton's transcription shows, the beginning of the text is broken and this missing portion may well have referred to Jupiter.

Britton states that the text was "possibly written in the 2<sup>nd</sup> half of the 7<sup>th</sup> century",<sup>159</sup> and probably in Babylon based on mentions of the text's author on other tablets. As with DT 78, which dates to approximately the same period, we see very early mentions of the Goal-Year periods of 8 years for Venus and 59 years for Saturn. Here we also see the first mention of a 47-year period for Mars.

#### 4.2.4 BM 33066 (LBAT \*\*1477, Strassmeier Cambyses 400)

This tablet, described by Britton as a "unique proto-almanac",<sup>160</sup> contains records of Lunar Six events, planetary phenomena, planetary conjunctions with the Moon or another planet, and lunar eclipses for year 7 of Cambyses; i.e. year -522/-521. The section on planetary phenomena also refers to a few events in year 8 and (the non-existent) year 9 of Cambyses.

Hunger & Pingree suggested that the tablet was written in the "late fifth or early fourth century B.C.",<sup>161</sup> i.e. more than a century after the period covered by the records. However,

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<sup>154</sup> Britton (2009), p.359.

<sup>155</sup> Gadd (1967), p. 52.

<sup>156</sup> Brown (2000), p. 193.

<sup>157</sup> Kugler (1907), pp. 45-47.

<sup>158</sup> Britton (2002), p. 59 and 61.

<sup>159</sup> Britton (2002) p. 26. Despite a later published remark dating the text to the "first half of the sixth century" (Britton 2008, p. 19), he now maintains that the 7<sup>th</sup> century date is substantially more likely (personal communication).

<sup>160</sup> Britton (2007b), p. 7.

<sup>161</sup> Hunger & Pingree (1999), p. 175.

Britton now believes that it was actually written during the reign of Cambyses, with two main arguments in his favour. Firstly, new evidence of the sophistication of early Lunar Six prediction techniques has arisen since Hunger & Pingree's book was published, proving that the necessary techniques to predict the lunar data were available in the 6<sup>th</sup> century BC.<sup>162</sup> Secondly, the references to Cambyses year 9 would be erroneous for any later astronomers writing about this time period (as Cambyses died in the 8<sup>th</sup> year of his reign), but would simply be a natural extension of dates for a scribe writing during Cambyses' reign.

Britton's analysis of the records suggest that the most likely periods used to predict the planetary events were 6 years for Mercury; 56 years for Venus; 32 years for Mars; 71 years for Jupiter; 59 years for Saturn. The Goal-Year periods of 8 years for Venus and 47 years for Mars are also analysed but considered to not fit the records as well. This text, then, appears to be the only example of the use of a 32-year period for Mars.

#### 4.2.5 BM 35402 (LBAT 1593)

This text is extremely unusual because of the exceptionally long planetary periods it suggests for Jupiter, Venus, Mars, Saturn and the Moon (but not Mercury) – periods of several hundred years in each case.<sup>163</sup> It was copied and discussed in SSB I by Kugler, who simply described it as “an astrological tablet”.<sup>164</sup> Kugler shows how the long periods can be represented as simple multiples of other attested periods. Note that Reiner has also translated this text and discussed its astrological content, but she does not include the planetary periods section which we are interested in here because of its previous study by Kugler.<sup>165</sup> The date of this text is unknown, although Sachs classifies it in LBAT under “Late Astrology”.

#### 4.2.6 BM 34560 (LBAT 1515)

The exact categorisation of this text's contents remains a mystery, as does its date. Sachs describes it in LBAT as a text of planetary periods, and categorises it as intermediate astronomy, i.e. “later than MÚL.APIN and earlier than ACT”.<sup>166</sup> More recently, Steele refers to it as a procedure text, “probably a late text”.<sup>167</sup> The most recent speculation is that LBAT 1515, rather than being a procedure text for the Goal-Year periods, is in fact an attempt to use the Goal-Year periods to analyse relative planetary and solar motion.<sup>168</sup> Whatever the methods were behind this obviously very intriguing text, it is clear that it contains references to the well-established planetary periods for Jupiter, Venus, Mercury and Saturn; hence its inclusion in this list.

#### 4.2.7 AO 6455 (TU 11)

This text is a collection of rules relating to planetary and lunar predictions, from Uruk. The majority of the contents are concerned with rules for astrology and for predicting lunar events; the lunar theories have been well analysed in Brack-Bernsen & Hunger's recent

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<sup>162</sup> For example, see Brack-Bernsen (1999a).

<sup>163</sup> Neugebauer & Sachs (1967), p. 206, also lists BM 40113 as a duplicate of these planetary periods.

<sup>164</sup> Kugler (1907), p. 48-53.

<sup>165</sup> Reiner (2000).

<sup>166</sup> Sachs (1955), p. xxxv.

<sup>167</sup> Steele (2009, forthcoming)

<sup>168</sup> J. M. Steele, personal communication.

translation and interpretation of the text.<sup>169</sup> Only one brief section of the text refers to the calculation of planetary periods, a section translated by Brack-Bernsen & Hunger as follows:

“In order for you to calculate (lit., “make”) rain and flood: 72 of Jupiter; 64, variant: 16, of Venus; 46, variant: 13, of Mercury; 59 of Saturn; 79, variant, 47, of Mars.”  
- AO 6455, Rev. 23 (Brack-Bernsen & Hunger (2002), p.16)

This suggests an attempt to associate recurrence of high river levels with planetary positions or events, which is slightly outside the scope of this work. Here, only the recurrence of the planetary events across these periods will be checked.<sup>170</sup> A few other sections of TU 11 refer to one or more of the planets; the meaning of these sections is more obscure, although they do not appear to be predicting planetary periods.

Brack-Bernsen and Hunger date TU 11 to the late 3<sup>rd</sup> century B.C., based on the scribe’s name in the colophon. However, Brack-Bernsen has argued that the rules it contains do not necessarily come from that date, but that they are a collection of old and new rules from much earlier in the period.<sup>171</sup> This means that it is impossible to suggest when the text’s planetary periods might have been in use; it could have been at any point of the Late Babylonian Period (up to the early Seleucid Era), or even earlier. Brack-Bernsen concludes that simply “How far back in time these rules were known, we do not know.”<sup>172</sup>

#### 4.2.8 BM 41004 (Atypical Text E<sup>173</sup>)

This is an interesting procedure text, containing: dates and procedures for relating lunar latitude and motion by Normal Stars, possibly a short (damaged) section of instructions concerning planetary conjunctions, and procedures for calculating planetary motion by Normal Stars (giving planetary periods in the form of a number of years plus a date or longitude correction). The periods and corrections are summarised, and have been thoroughly analysed, by Neugebauer & Sachs.<sup>174</sup> More recently, Brack-Bernsen and Hunger have published a translation of this text.<sup>175</sup>

The exact date of Atypical Text E is not known, and the authors do not suggest one, although Neugebauer & Sachs do state that the (lunar) “longitudes refer to a period of about 500 B.C.”.<sup>176</sup> The tablet’s colophon reads: “Tablet of Marduk-šāpik-zēri, son of Bēl-apla-idinna, descendant of Mušēzib, [written by] the hand of Iddin-Bēl, son of Marduk-šāpik-[zeri, descendant] of Mušēzib”;<sup>177</sup> the same names occur in the colophon to Atypical Text F,<sup>178</sup> which is also undated. Robson discusses this family, whose names occur on the colophons of several important texts.<sup>179</sup> Based on the fact that one of these important texts is a copy of *Emūma Anu Enlil* I, apparently written by Marduk-šāpik-zēri in SE 142,<sup>180</sup> it

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<sup>169</sup> Brack-Bernsen & Hunger (2002).

<sup>170</sup> For further discussion of related matters, see for example Hunger (1976) for a study of TU11 and other texts which connect planetary motion and weather events, and Slotsky (1997) for an analysis of river level data from the Diaries.

<sup>171</sup> Brack-Bernsen (2002).

<sup>172</sup> Brack-Bernsen (1999a), p. 175.

<sup>173</sup> Named following its inclusion in Neugebauer & Sachs (1967).

<sup>174</sup> Neugebauer & Sachs (1967), pp 200-208.

<sup>175</sup> Brack-Bernsen & Hunger (2006).

<sup>176</sup> Neugebauer & Sachs (1967), p. 204.

<sup>177</sup> Neugebauer & Sachs (1967), p. 207.

<sup>178</sup> Neugebauer & Sachs (1967), p. 208-210.

<sup>179</sup> Robson (2008), pp 220-227.

<sup>180</sup> Verderame (2002), p. 49.



seems reasonable to estimate that Atypical Text E is also from the early 2<sup>nd</sup> century BC.

#### 4.2.9 The Astronomical Cuneiform Texts

For completeness, the planetary periods from the ACT procedure texts are also included here. As described in Chapter 1, these procedure texts mostly contain instructions for calculating longitudes and other phenomena of planetary motion; here we are interested in the relatively few which also list the number of years between a certain number of a planet's phenomena. These are tabulated below:

| Planet  | Period (in Babylonian years) | Period is found in <i>ACT</i> numbers |
|---------|------------------------------|---------------------------------------|
| Mercury | 46                           | 800                                   |
|         | 355                          | 816                                   |
| Venus   | 8                            | 815                                   |
| Mars    | 47                           | 811                                   |
|         | 79                           | 811                                   |
|         | 264                          | 811, 811a                             |
| Jupiter | 12                           | 811, 813, 814                         |
|         | 71                           | 812, 813, 814                         |
|         | 83                           | 812, 813                              |
|         | 95                           | 812                                   |
|         | 166                          | 813                                   |
|         | 261                          | 812                                   |
|         | 427                          | 812, 813, 814                         |
| Saturn  | 265                          | 801, 802, 819c                        |

**Table 4.1: a summary of the planetary periods referred to in the Astronomical Cuneiform Texts.**

The dates in which individual procedure texts were written are not generally known. The *ACT* planetary ephemerides date from at least SE 4 to 303, and so it seems reasonable to estimate based on this that an *ACT* procedure text could date from any part of the Seleucid Era.

#### 4.2.10 A summary of the planetary periods from the procedure texts

Table 4.2 on the following page is a summary of the above sections, collecting together and giving details of the periods attested in the various texts for each of the planets.<sup>181</sup>

<sup>181</sup> This table is adapted from Steele (2009, forthcoming).

| Text                             | Mercury  | Venus  | Mars   | Jupiter   | Saturn  |
|----------------------------------|--|--|--|---|---|
| Goal-Year<br>Texts               | 46 years                                       | 8 years  | 79 years<br>(phenomena)<br>47 years<br>(passages)                    | 71 years<br>(phenomena)<br><br>83 years (passages)  | 59 years  |
| BM 92685<br>(DT 78)              | 60 years?<br>13 years?                         | 8 years  | 15 years   | 71 years<br>12 years?   | 59 years  |
| BM 45728                         | 6yr + 10 days                                  | 8yr - 4 days   | 47yr + 12 days   |   | 59 years  |
| BM 33066<br>(Cambyses text)      | 6 years  | 8 or 56 years  | 32 or 47 years   | 71 years  | 59 years  |
| BM 35402<br>(LBAT 1593)          |  | 6400 years   | 284 years  | 344 years   | 560 years   |
| BM 34560<br>(LBAT 1515)          | 46 years                                       | 8yr - 4 days   |  | 71yr - 5°<br>83yr - 7 days<br>12yr + 6°   | 59yr - 5 days   |
| TU 11                            | 13 years<br>46 years                           | 16 years<br>64 years   | 79 years<br>47 years   | 72 years  | 59 years  |
| BM 41004<br>(Atypical Text<br>E) | 13yr - 3 days<br><br>46yr - 1 day<br><br>125yr | 8yr - 4 days<br><br>16yr - 2 days<br>48 yr + 2<br>days<br>64yr + 1 or 2<br>days<br>8yr - 4°<br>16yr - 2° | 32yr - 5 days<br><br>47yr + 4 days<br><br>64yr + 4 days<br><br>126yr | 12yr - 1 month<br><br>12yr + 5°<br><br>71yr<br><br>83yr - 7 days  | 59yr - 6 days<br><br>30yr + 9 days<br><br>30yr + 7°;20<br><br>147yr |
| ACT                              | 46 years<br>355 years                          | 8 years  | 47yr ...<br>79yr ...<br>284 years                                    | 12yr + 4°;10<br>71yr - 5° (slow arc)<br>71yr - 6° (fast arc)<br>83yr - 1°<br>95yr + 4°<br>166yr?<br>261yr + 4°<br>427 years | 265 years   |

**Table 4.2: a summary of attested planetary periods (and corrections to date or longitude when given) from all of the procedure texts**

In short, the following periods of Babylonian years are attested in at least one text:

|         |  |
|---------|--|
| Mercury | 6, 13, 46, 60, 125, 355 years                |
| Venus   | 8, 16, 48, 56, 64, 6400 years                |
| Mars    | 15, 32, 47, 64, 79, 126, 284 years           |
| Jupiter | 12, 71, 72, 83, 95, 166, 261, 344, 427 years |
| Saturn  | 30, 59, 147, 265, 560 years                  |

Venus' 6400 year period is not considered further here because it is outstandingly infeasible that the period was ever used in practice, particularly since the Late Babylonian Period was only around 800 years long. Note that some of the texts specify whether the period applies to Greek-letter phenomena or to Normal Star passages, but many of them do not. Therefore, each of these periods will be checked using both phenomena and passages. Note also that, while Table 4.2 includes all the attested periods and their corrections to dates<sup>182</sup> or longitudes, only the date corrections are analysed in this chapter and not the mathematical longitude changes.

### ***4.3 How can we define how effective a planetary period is?***

One might reasonably assume that the Babylonian astronomers chose the periods which worked the “best” for their own calculations – but how can we define what criteria might have led to this? Below I outline a few criteria which I believe it would have been necessary to take into account. By assessing how effective each of the various attested periods is – in other words, how well each period predicts events when considered against all of these criteria together – this will lead towards a better understanding of how the Babylonian astronomers settled on their chosen Goal-Year Text planetary periods.

We can infer several criteria which could be used to assess a period's usability by thinking about how the Babylonian astronomers would have used the planetary periods to make predictions.<sup>183</sup> Here are outlined five such criteria:

- i. How consistent the period is for predicting dates of events. As we have seen from Table 4.2, the period does not have to be an exact number of Babylonian years. However, there should be consistency about what specific date correction is necessary. For example, when testing our hypothetical period of Y years - 4 days, we would expect that the majority of events would recur with a date close to 4 days earlier in the year Y years later. If instead we found that the *observed* date differences for equivalent events Y years apart varied apparently randomly between, say,  $\pm 30$  days, then we could say that this would not be a very accurate period.

In addition, different events will have a different tolerance regarding how accurate the date correction needs to be. For example, Mercury moves particularly fast (on average about  $1^\circ$  of longitude a day) and so a period used to predict its Normal Star passages would need to be very accurate and consistent in predicting the right day, because even one day later Mercury will have moved a substantial distance away from the star. On the other hand, Saturn is extremely slow-moving and will often barely seem to move for a month or more around a stationary point. This makes it a lot more difficult to decide, both for the Babylonian astronomers and for modern readers attempting to assess their methods, on exactly which day the stationary point should be recorded. Nevertheless, it does mean that there is more flexibility about how closely the date correction predicts the “true” date of the stationary point.

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<sup>182</sup> From here on the number of days by which a planetary period differs from a full number of Babylonian years will be referred to as a *date correction*. For example, for a hypothetical attested period of Y years - 4 days, the date correction would be -4 days.

<sup>183</sup> Again, note that this is *not* drawing any direct conclusions about how the Babylonian astronomers chose which periods to use, or their thought processes. These criteria are just some that a modern observer might use to test whether predictions made using Babylonian Goal-Year methods gave an “accurate” result or not (and determine how we might define its accuracy).

- ii. How consistent the period is for predicting planet-Normal Star distances at the time of a Normal Star passage. None of the procedure texts refer to any correction for these distances, so it seems most likely that the Babylonian astronomers did not expect to apply any corrections to the distance measurements when making predictions. (See Chapter 5 for further discussion of this.) If this is the case, then it is necessary to check how the latitude difference between the planet and the star changes after the planetary period has passed, allowing for precession.<sup>184</sup>
- iii. How long the period is: assuming a period is accurate enough, a shorter period is preferable to a longer one. This is simply because a shorter period means it is much quicker to turn observed events into predictions for future years. Shorter periods can also be deduced sooner and date corrections can be improved more quickly if future observations do not quite agree with predictions.

This point is less important than i) and ii), in part because we assume that the Babylonian astronomers had a good archive of previous Diaries available. So it would be possible to copy out all observations relating to one planet for many decades and use this to deduce patterns in its motion; indeed, it is very likely that this is one purpose of some of the texts found in *ADART* Vol. V. Equally, some of the longer planetary periods are formed by combining multiples of shorter ones<sup>185</sup> and so it would not be necessary to have, eg, 400 years of Diary observations before a 400-year planetary period could be discovered. However, it would of course still take a very long time to *test* a period of 400 years observationally.

- iv. What date correction is needed: all other things being equal, a planetary period which is an exact number of Babylonian years long, or only needs a very small date correction, will be more convenient to use than one which requires a larger number of days adding to or subtracting from the date of each predicted event.
- v. If possible, a planetary period which works well for predicting both Greek-letter phenomena and Normal Star passages would be more convenient than using a separate period for each type of event.

Clearly, points i) and ii) are the most important – if the suggested date correction only predicts the right date a low percentage of the time, then how easy the period is to use, as points iii) to v) assess, is much less significant.

The following sections assess these points with the use of theoretical event data taken from Roughton's tables.<sup>186</sup> For each planetary period, a number of calculated dates of Greek-letter phenomena and Normal Star passages were compared with the dates of the equivalent events a planetary period later. For Normal Star passages, the latitudes of the star and the planet at the time of each event were also compared. The number of records

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<sup>184</sup> As stated in Chapter 3 and Jones (2004), the Babylonians' planet-star distance measurements were not purely a latitude difference, but instead would have been a function of both planetary latitude and longitude. Nevertheless it is still appropriate to check the latitude difference in this case: we know that the longitude will be approximately the same for both events because the planet is moving past the same Normal Star; therefore, the change in latitude will provide the best indication of whether the planet-star distance has changed.

<sup>185</sup> For example, Neugebauer & Sachs (1967), p.207 shows how this could have been done using the periods in Atypical Text E. One example for Mercury: the text gives periods of 13year - 3 days, 46 years - 1 day and 125 years exactly. 125years can be made from  $3 \times 46 - 13 = 125$ ; and  $3 \times (-1) - (-3) = 0$ .

<sup>186</sup> Roughton (2002); as before, see §1.4.3.

used for each analysis varied: the records spanned at least a complete Goal-Year period for each planet. Normal Star passages that took place when the planet was in a period of invisibility from Babylon were removed from the analysis.

The tables and figures in the following sections summarise the results of this analysis, showing the “average” date correction for each period, in terms of both the mean and the modal theoretical date correction. Including both of these date corrections is useful to give a fuller assessment of how well the period worked: in practice, the further apart the mean and the modal corrections are, the more skewed the set of calculated date corrections is, meaning that the period is less likely to be a good fit. Equally, since we do not know exactly what the methods used by the Babylonian astronomers would have used to determine the date correction for a planetary period, it is best practice to consider a range of possibilities.

This does not imply that the Babylonians literally used the modern statistical concepts of a dataset’s mean or mode in their astronomical predictions. It is important not to forget that these terms belong to modern statistics rather than Babylonian astronomy, and one must be careful to avoid ascribing modern terminology and methods to ancient scientists. However, one may be tempted to speculate that “inspection of a planet’s excerpted observational records to determine the most common date difference” would be a method very much in keeping with what else we know of Goal-Year methods of prediction.<sup>187</sup> Determining a date correction using this process would produce a result extremely similar to the modal value of a modern dataset; it would, crucially, be anachronistic to *call* their result the “mode”.

The tables in the following sections also show what percentage of the theoretical date differences fall within  $\pm 1$  day<sup>188</sup> and  $\pm 3$  days either side of each theoretical date correction. As point i) in this section discussed, we might expect an effective planetary period for an inferior planet to have a high percentage of the events recur within  $\pm 1$  day of the date correction, and an effective period for a superior planet to have a high percentage of events recur within  $\pm 3$  days of the date correction. All of the calculated theoretical dates are given to the nearest day, since Babylonian observations are only generally recorded to the nearest day.<sup>189</sup>

Note that in the following tables the periods will be given in lunar months as well as Babylonian years. This is because (as we shall see in Chapter 6) the Babylonian system of intercalary months means that a period of Babylonian years does not always cover the same length of time when measured in lunar months. Since the periods of the planets’ motions will naturally *not* vary with the Babylonian calendar, it reduces confusion to record the periods in units of lunar months ( $\pm$  a date correction when necessary). A Babylonian year is always a whole number of lunar months long and so the date correction will not be any different for a period quoted in lunar months or in Babylonian years.

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<sup>187</sup> For example, text BM 36823 (*ADART* Vol. V, No. 54) contains Jupiter records at 12-year intervals arranged in columns – see Steele (2009) – which would be a useful way of presenting the records if an astronomer wished to examine the differences in date between equivalent events 12 years apart.

<sup>188</sup> I.e. the day itself, plus one day earlier or later.

<sup>189</sup> It is true that the usual format of a Normal Star passage says whether it was observed in the “first” or “last part of the night”. However, note that this says absolutely nothing about the planets’ *true* time of passage, i.e. the calculated exact point at which it passes the star (however that may have been defined). The “first/last part of the night” simply recorded whether the planet was above the horizon earlier or later in the night at the time of passage, as discussed in §1.3.5.4. In my opinion we cannot be completely certain that the Babylonian astronomers would have observed an event on the exact day suggested by rounding off a modern calculated date, rather than one day earlier or later.

#### 4.4 How well do the planetary periods predict dates of Greek-letter phenomena?

Table 4.3a summarises the theoretical date corrections for Mercury's Greek-letter phenomena. Several of these periods work extremely effectively, with almost all of the events occurring within 1 day of the suggested date correction after 13, 46, 125 or 355 years. Out of these four periods, we can speculate (using the five criteria outlined in §4.3) that the 46-year Goal-Year period was chosen because it is accurate, conveniently short, and needs very little correction to the dates of phenomena.

Table 4.3b summarises the theoretical date corrections for Venus' Greek-letter phenomena. From the results one would suggest that the 8-year Goal-Year period was chosen because it is conveniently short and also very accurate, with the longer periods showing no increase in accuracy.

Table 4.3c summarises the theoretical date corrections for Mars' Greek-letter phenomena. It shows that Mars' phenomena do not recur as precisely as Mercury's or Venus'. Clearly most of the shorter attested periods for Mars are somewhat imprecise: compared with Mercury and Venus, where the most common date correction would be within a few days of all of the records, for Mars there is a wider range of date differences. 79 years and 284 years are the only periods which recur reasonably accurately, and 284 is inconveniently long which makes the 79-year Goal-Year period an obvious choice.

Table 4.3d summarises the theoretical date corrections for Jupiter's Greek-letter phenomena. Unlike Mars, Jupiter's events recur very closely over nearly all of the periods suggested (except 72 years), and so in terms of accuracy any of the periods could have been chosen as a Goal-Year period. Using the criteria from §4.3, we could speculate that the 71-year Goal-Year period was chosen because, as with Mercury, it fulfils all the criteria of being very accurate, conveniently short, and needing very little correction to the dates of phenomena.

Table 4.3e summarises the theoretical date corrections for Saturn's Greek-letter phenomena. As with Jupiter, most of the periods suggested are extremely accurate. Using our criteria to eliminate the periods over 100 years, there does not seem to be much to choose between 30 and 59 years in terms of accuracy. The 59-year Goal-Year period is slightly more accurate when considering how many phenomena dates recur to within  $\pm 1$  day of the date correction, but as we have previously established this is less significant because of Saturn's slow motion, and the difficulty involved with determining the correct date of stationary points.

| Period           |              | Mean date correction |                               |                                | Modal date correction |                               |                                |
|------------------|--------------|----------------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| Babylonian years | Lunar months | Date correction      | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days | Date correction       | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days |
| 6                | 74           | +16                  | 77                            | 95                             | +16                   | 77                            | 95                             |
| 13               | 161          | -3                   | 96                            | 99                             | -3                    | 96                            | 99                             |
| 46               | 569          | -0                   | 96                            | 100                            | -1                    | 99                            | 100                            |
| 60               | 742          | -10                  | 63                            | 94                             | -9                    | 65                            | 94                             |
| 125              | 1546         | +2                   | 99                            | 100                            | +3                    | 98                            | 100                            |
| 355              | 4391         | +1                   | 90                            | 97                             | +1                    | 90                            | 97                             |

**Table 4.3a: a summary of the date corrections to Mercury's Greek-letter phenomena dates, across each of the planetary periods attested in the procedure texts.**

| Period           |              | Mean date correction |                               |                                | Modal date correction |                               |                                |
|------------------|--------------|----------------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| Babylonian years | Lunar months | Date correction      | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days | Date correction       | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days |
| 8                | 99           | -4                   | 98                            | 100                            | -3                    | 99                            | 100                            |
| 16               | 198          | -8                   | 98                            | 100                            | -8                    | 98                            | 100                            |
| 48               | 593          | +6                   | 67                            | 95                             | +7                    | 75                            | 98                             |
| 56               | 692          | +3                   | 70                            | 91                             | +3                    | 70                            | 91                             |
| 64               | 791          | -1                   | 69                            | 89                             | -1                    | 69                            | 89                             |

**Table 4.3b: as Table 4.3a, for Venus' Greek-letter phenomena**

| Period           |              | Mean date correction |                               |                                | Modal date correction |                               |                                |
|------------------|--------------|----------------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| Babylonian years | Lunar months | Date correction      | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days | Date correction       | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days |
| 15               | 185          | -3                   | 10                            | 26                             | +2                    | 38                            | 59                             |
| 32               | 396          | +5                   | 19                            | 63                             | +2                    | 51                            | 70                             |
| 47               | 581          | +2                   | 29                            | 81                             | +4                    | 57                            | 72                             |
| 64               | 792          | +10                  | 9                             | 23                             | +4                    | 32                            | 57                             |
| 79               | 977          | +7                   | 87                            | 97                             | +6                    | 83                            | 96                             |
| 126              | 1558         | +8                   | 32                            | 89                             | +10                   | 63                            | 79                             |
| 284              | 3513         | -7                   | 87                            | 99                             | -7                    | 87                            | 99                             |

**Table 4.3c: as Table 4.3a, for Mars' Greek-letter phenomena**

| Period           |              | Mean date correction |                               |                                | Modal date correction |                               |                                |
|------------------|--------------|----------------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| Babylonian years | Lunar months | Date correction      | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days | Date correction       | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days |
| 12               | 148          | +17                  | 91                            | 100                            | +18                   | 100                           | 100                            |
| 71               | 878          | +0                   | 97                            | 100                            | +1                    | 94                            | 100                            |
| 72               | 891          | +15                  | 36                            | 88                             | +13                   | 45                            | 65                             |
| 83               | 1026         | +17                  | 100                           | 100                            | +17                   | 100                           | 100                            |
| 95               | 1175         | +5                   | 100                           | 100                            | +5                    | 100                           | 100                            |
| 166              | 2053         | +5                   | 100                           | 100                            | +5                    | 100                           | 100                            |
| 261              | 3228         | +11                  | 99                            | 100                            | +10                   | 99                            | 100                            |
| 344              | 4255         | -1                   | 100                           | 100                            | -1                    | 100                           | 100                            |
| 427              | 5281         | +16                  | 100                           | 100                            | +16                   | 100                           | 100                            |

**Table 4.3d: as Table 4.3a, for Jupiter's Greek-letter phenomena**

| Period           |              | Mean date correction |                               |                                | Modal date correction |                               |                                |
|------------------|--------------|----------------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| Babylonian years | Lunar months | Date correction      | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days | Date correction       | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days |
| 30               | 371          | +9                   | 96                            | 100                            | +9                    | 96                            | 100                            |
| 59               | 730          | -6                   | 99                            | 100                            | -6                    | 99                            | 100                            |
| 147              | 1818         | +3                   | 100                           | 100                            | +3                    | 100                           | 100                            |
| 265              | 3278         | -8                   | 97                            | 100                            | -7                    | 100                           | 100                            |
| 560              | 6926         | +22                  | 80                            | 100                            | +21                   | 89                            | 100                            |

**Table 4.3e: as Table 4.3a, for Saturn's Greek-letter phenomena**

#### ***4.5 How well do the planetary periods predict dates of Normal Star passages?***

In general, planetary periods do not recur as accurately for Normal Star passages as they do for Greek-letter phenomena. This is particularly apparent around stationary points: if a stationary point does not happen at close to the same longitude in the observation year and the year one planetary period later – even in a period which is otherwise very accurate – the dates of Normal Star passages will vary greatly from each other around the stationary points. (This will be illustrated and discussed further in Chapter 5.)

Table 4.4a summarises the theoretical date corrections for Mercury’s Normal Star passages. Again, it is clear that the 46-year Goal-Year period is the most accurate overall, being conveniently short and needing very little correction to passage dates.

Table 4.4b summarises the theoretical date corrections for Venus’ Normal Star passages. Again, we find the same situation as with Venus’ phenomena dates: the 8-year Goal-Year period is the most accurate, with the longer periods showing no increase in accuracy. Once again, this period is also conveniently short and needs very little correction to passage dates, making it the obvious choice.

Table 4.4c summarises the theoretical date corrections for Mars’ Normal Star passages. As with the phenomena dates, Mars’ passage dates do not recur as precisely as Mercury’s or Venus’. In terms of the accuracy of the date corrections to within  $\pm 3$  days, there is little difference between that of Mars’ Goal-Year period for Normal Star passages, 47 years, and its 79-year phenomena period. (Again, 284 years is slightly more accurate but is inconveniently long.) Since the date correction for the 79 year period (+3 days) is more convenient than the 47 year period (+14 or 15 days), it remains uncertain why the Babylonian astronomers chose to use 47 years in the Goal-Year Texts rather than using the equally accurate 79-year period for both types of event.

Table 4.4d summarises the theoretical date corrections for Jupiter’s Normal Star passages. Note that the 72-year period from text TU11 is not included on the table because it literally does not work at all (i.e., the date corrections would be a year long).

Unlike Mars, in this case it is immediately clear why different periods were used for Jupiter’s phenomena and passages. Most of the suggested periods are not very accurate at all, and the 71-year period which was used for phenomena would not be as good a choice here. The most accurate period for Jupiter’s Normal Star passages, apart from the extremely long ones, is certainly the 83-year Goal-Year period. Thus it seems quite logical that different periods were used for the two types of event.

Table 4.4e summarises the theoretical date corrections for Saturn’s Normal Star passages. Note that the 30-year period from Atypical Text E is not included on this table because it does not work for Normal Star passages at all.

None of the suggested periods is particularly accurate for predicting passages. However, of the options, the 59-year Goal-Year period is clearly preferable in terms of accuracy and length of period, so it makes sense that it was used.



| Period              |                 | Mean date correction |                                     |                                      | Modal date correction |                                     |                                      |
|---------------------|-----------------|----------------------|-------------------------------------|--------------------------------------|-----------------------|-------------------------------------|--------------------------------------|
| Babylonian<br>years | Lunar<br>months | Date<br>correction   | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days | Date<br>correction    | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days |
| 6                   | 74              | +8                   | 33                                  | 90                                   | +10                   | 69                                  | 83                                   |
| 13                  | 161             | -5                   | 87                                  | 96                                   | -5                    | 87                                  | 96                                   |
| 46                  | 569             | -1                   | 99                                  | 100                                  | -1                    | 99                                  | 100                                  |
| 60                  | 742             | -4                   | 12                                  | 33                                   | -1                    | 55                                  | 71                                   |
| 125                 | 1546            | +3                   | 93                                  | 98                                   | +4                    | 96                                  | 99                                   |
| 355                 | 4391            | -0                   | 93                                  | 95                                   | -0                    | 93                                  | 95                                   |

**Table 4.4a: a summary of the date corrections to Mercury’s Normal Star passage dates, across each of the planetary periods attested in the procedure texts.**

| Period              |                 | Mean date correction |                                     |                                      | Modal date correction |                                     |                                      |
|---------------------|-----------------|----------------------|-------------------------------------|--------------------------------------|-----------------------|-------------------------------------|--------------------------------------|
| Babylonian<br>years | Lunar<br>months | Date<br>correction   | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days | Date<br>correction    | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days |
| 8                   | 99              | -2                   | 88                                  | 97                                   | -1                    | 92                                  | 97                                   |
| 16                  | 198             | -3                   | 92                                  | 96                                   | -4                    | 86                                  | 94                                   |
| 48                  | 593             | +19                  | 83                                  | 90                                   | +19                   | 83                                  | 90                                   |
| 56                  | 693             | -12                  | 79                                  | 90                                   | -13                   | 78                                  | 87                                   |
| 64                  | 791             | +16                  | 63                                  | 92                                   | +15                   | 82                                  | 89                                   |

**Table 4.4b: as Table 4.4a, for Venus’ Normal Star passages**

| Period              |                 | Mean date correction |                                     |                                      | Modal date correction |                                     |                                      |
|---------------------|-----------------|----------------------|-------------------------------------|--------------------------------------|-----------------------|-------------------------------------|--------------------------------------|
| Babylonian<br>years | Lunar<br>months | Date<br>correction   | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days | Date<br>correction    | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days |
| 15                  | 186             | -2                   | 16                                  | 46                                   | -4                    | 57                                  | 74                                   |
| 32                  | 395             | +18                  | 50                                  | 87                                   | +20                   | 62                                  | 81                                   |
| 47                  | 581             | +15                  | 60                                  | 87                                   | +14                   | 76                                  | 86                                   |
| 64                  | 791             | +6                   | 20                                  | 69                                   | +9                    | 59                                  | 75                                   |
| 79                  | 977             | +3                   | 86                                  | 90                                   | +3                    | 86                                  | 90                                   |
| 126                 | 1559            | -12                  | 78                                  | 87                                   | -12                   | 78                                  | 87                                   |
| 284                 | 3513            | -6                   | 89                                  | 97                                   | -6                    | 89                                  | 97                                   |

**Table 4.4c: as Table 4.4a, for Mars’ Normal Star passages**

| Period              |                 | Mean date correction |                                     |                                      | Modal date correction |                                     |                                      |
|---------------------|-----------------|----------------------|-------------------------------------|--------------------------------------|-----------------------|-------------------------------------|--------------------------------------|
| Babylonian<br>years | Lunar<br>months | Date<br>correction   | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days | Date<br>correction    | Percentage<br>within $\pm 1$<br>day | Percentage<br>within $\pm 3$<br>days |
| 12                  | 148             | -1                   | 0                                   | 1                                    | +3                    | 26                                  | 42                                   |
| 71                  | 879             | -9                   | 0                                   | 0                                    | -3                    | 30                                  | 44                                   |
| 83                  | 1027            | -9                   | 7                                   | 55                                   | -7                    | 55                                  | 67                                   |
| 95                  | 1174            | +23                  | 0                                   | 1                                    | +18                   | 35                                  | 50                                   |
| 166                 | 2053            | +12                  | 0                                   | 22                                   | +15                   | 40                                  | 57                                   |
| 261                 | 3228            | +6                   | 2                                   | 43                                   | +3                    | 53                                  | 64                                   |
| 344                 | 4255            | -3                   | 37                                  | 66                                   | -4                    | 56                                  | 69                                   |
| 427                 | 5281            | +17                  | 65                                  | 89                                   | +17                   | 65                                  | 89                                   |

**Table 4.4d: as Table 4.4a, for Jupiter’s Normal Star passages**

| Period           |              | Mean date correction |                               |                                | Modal date correction |                               |                                |
|------------------|--------------|----------------------|-------------------------------|--------------------------------|-----------------------|-------------------------------|--------------------------------|
| Babylonian years | Lunar months | Date correction      | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days | Date correction       | Percentage within $\pm 1$ day | Percentage within $\pm 3$ days |
| 59               | 730          | -10                  | 0                             | 5                              | -15                   | 32                            | 52                             |
| 147              | 1819         | -7                   | 0                             | 0                              | +9                    | 13                            | 30                             |
| 265              | 3278         | -1                   | 0                             | 0                              | +16                   | 11                            | 24                             |
| 560              | 6926         | +8                   | 3                             | 9                              | +4                    | 16                            | 33                             |

Table 4.4c: as Table 4.4a, for Saturn's Normal Star passages

## 4.6 How well do the planetary periods predict planet-Normal Star distances?

As explained above, the accuracy of dates is not the only factor concerning Normal Star passage predictions. As well as a recurrence of longitude, an effective planetary period needs to be one over which the planet's latitude also recurs. Otherwise, accurate predictions of planet-Normal Star distances will be impossible.

The following figures show, for each period, how much the planet-star latitude difference changes for occurrences of the same passage one period apart.<sup>190</sup> On each histogram, the black column shows the Goal-Year Text period.

The latitude differences are shown in terms of fingers, the smallest Babylonian unit of astronomical distance as outlined in Chapter 1. The frequency of record comparisons which show a latitude change of less than 1 finger, a change of between 1 and 2 fingers, etc, are shown. In these figures the most important test of how well a period works is the percentage of records with a latitude change of less than 1 finger: since the finger is the smallest unit used by the Babylonian astronomers, only the records in this category would *not* predict an inaccurate measurement for the same event a planetary period later.<sup>191</sup>

Figure 4.1a summarises the latitude differences for Mercury's Normal Star passages. It shows that the 46-year Goal-Year period is unambiguously the most accurate in terms of latitude recurrence.

Figure 4.1b summarises the latitude differences for Venus' Normal Star passages. As with Mercury, the latitudes recur most accurately across the 8-year Goal-Year period

Figure 4.1c summarises the latitude differences for Mars' Normal Star passages. In this case it is odd that the 47-year Goal-Year period is *not* the period across which the latitudes recur most accurately. The 79-year period used for dates of Greek-letter phenomena would again have been a better fit, and it remains a mystery why this period was not also used for Normal Star passages.

Figure 4.1d summarises the latitude differences for Jupiter's Normal Star passages. Jupiter's latitudes tend to recur very accurately for almost all of the suggested periods, and the 83-year Goal-Year period is by far the best of the shorter periods (i.e. those under 100 years long). Note that the 71-year Greek-letter phenomena period is significantly the worst in terms of latitude recurrence, demonstrating again why the Babylonian astronomers used two different periods for predicting Jupiter's motion.

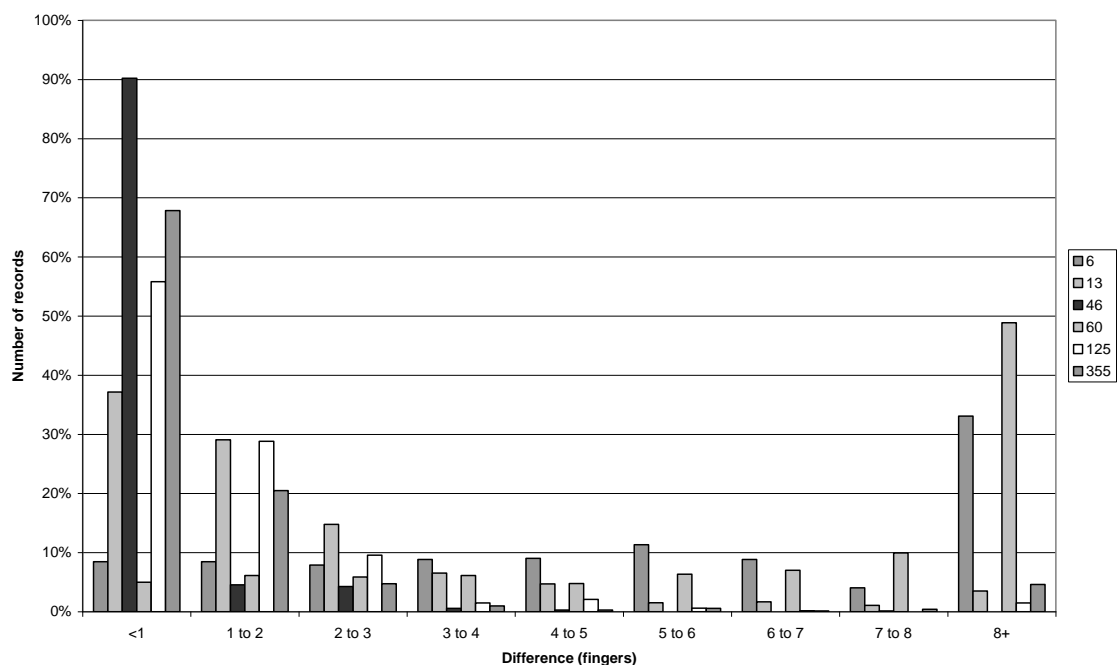
<sup>190</sup> Allowing for precession, as explained earlier.

<sup>191</sup> In reality, this criterion is almost certainly too strict. As Jones (2004) showed, larger planet-star distances were not recorded to an accuracy of a finger and a measurement of "4 cubits" could well refer to a range of distances between 3 ½ and 4 ½ cubits. Therefore, not *all* of the records in the figures with a latitude difference of even several fingers would necessarily result in an inaccurate prediction of a planet-star distance.

Figure 4.1e summarises the latitude differences for Saturn’s Normal Star passages. As with Jupiter, all of the periods tend to show a close recurrence of latitude; but the 59-year Goal-Year period is clearly the best, with almost all of the events being at the same latitude to within 1 finger, and none showing a latitude difference of more than 2 fingers.

It is likely that this explains why 59 years was used for Saturn’s Greek-letter phenomena as well. As discussed above, 30 years and 59 years were equally effective periods for Saturn’s phenomena, but for Normal Star passage predictions the 30-year period is not very effective at all, and so the 59-year period is clearly superior.

In summary, this section has demonstrated how the various planetary periods compare with each other by looking at what criteria the Babylonian astronomers may have used. By considering how closely dates of events and distances of Normal Star passages recur across the periods, combined with how convenient the periods are to use, this has led to a possible understanding of why the particular periods found in the Goal-Year Texts were chosen by their compilers.



**Figure 4.1a:** a summary of the latitude changes for Mercury’s Normal Star passages, across each of the planetary periods attested the procedure texts. The period used in the Goal-Year Texts is highlighted in black.

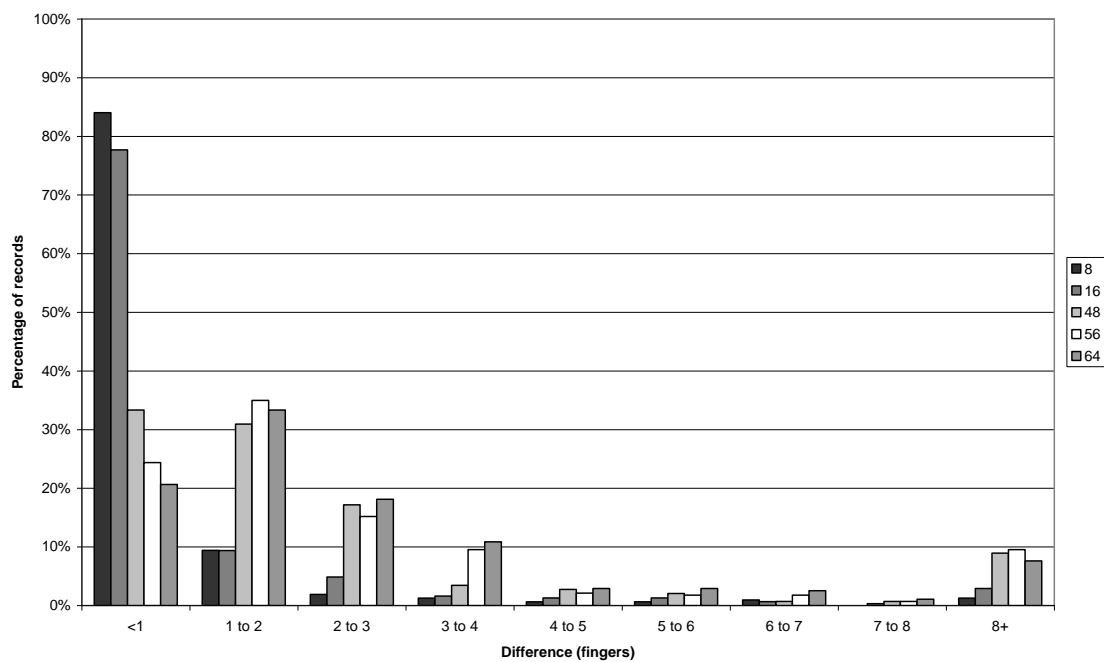


Figure 4.1b: as Figure 4.1a, for Venus' Normal Star passages

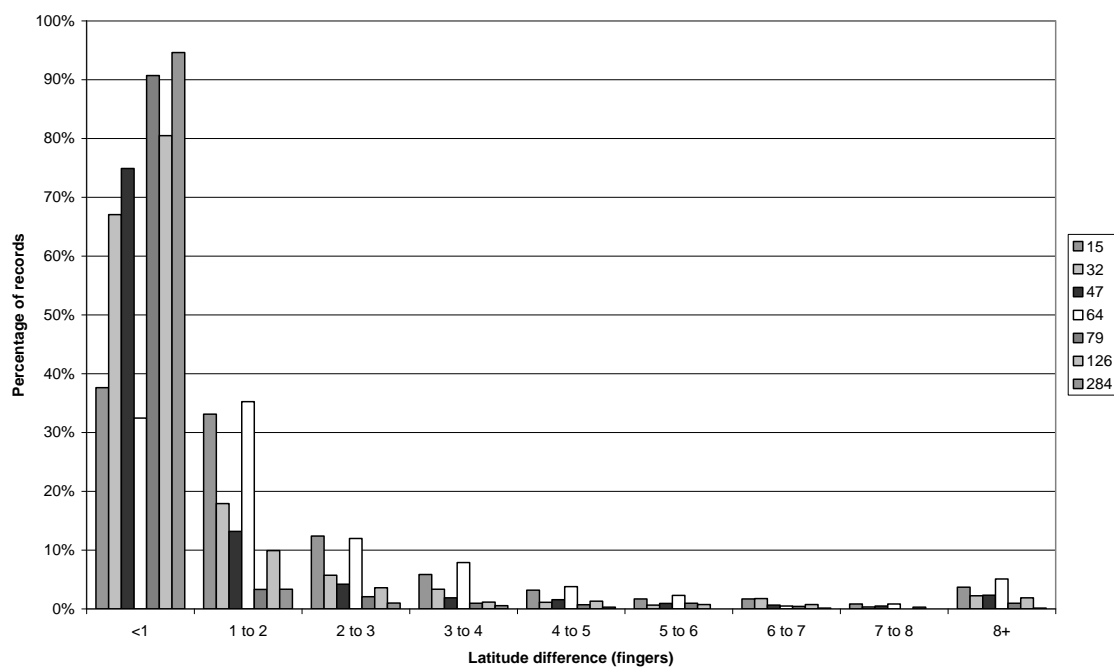


Figure 4.1c: as Figure 4.1a, for Mars' Normal Star passages

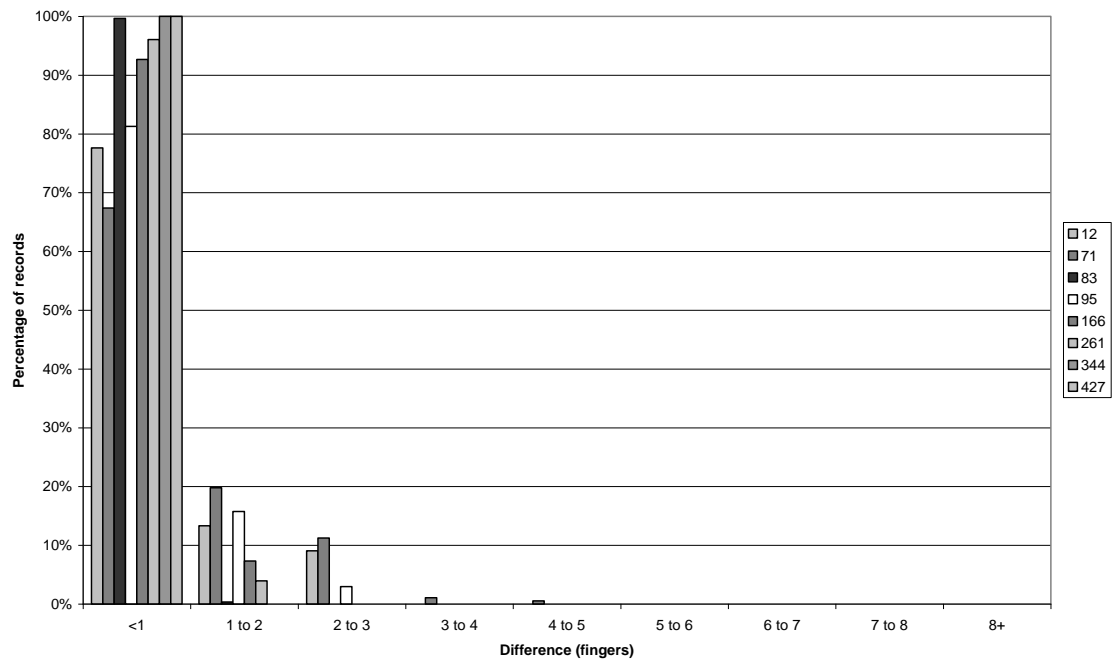


Figure 4.1d: as Figure 4.1a, for Jupiter's Normal Star passages

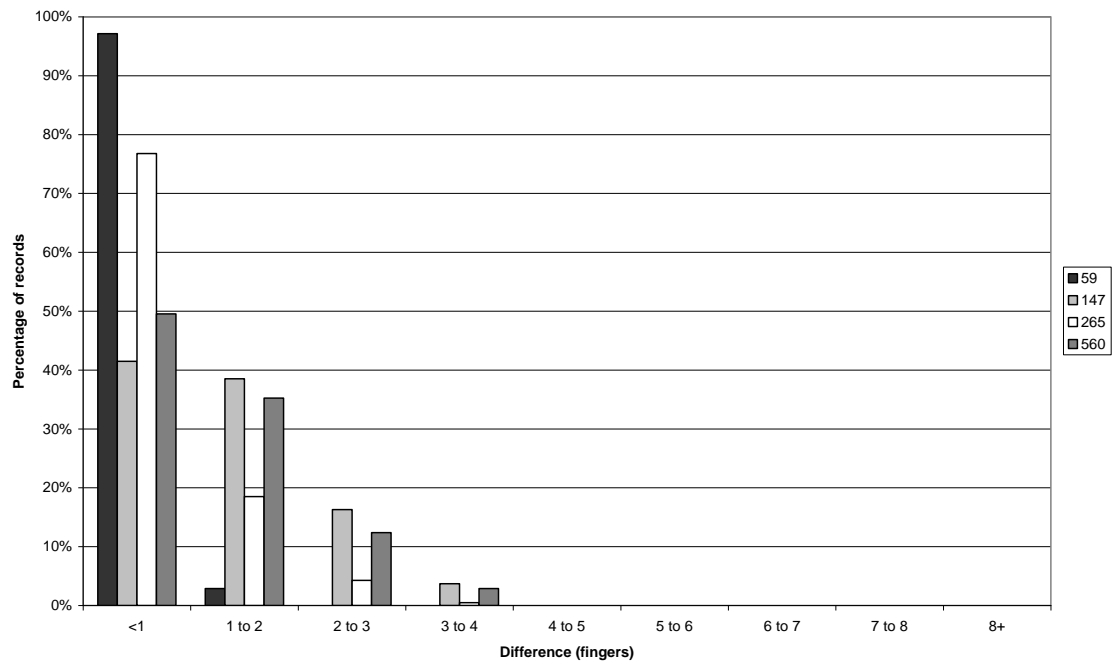


Figure 4.1e: as Figure 4.1a, for Saturn's Normal Star passages

#### 4.7 A comparison of the theoretical date corrections with the procedure texts' records

Having shown which periods and date corrections from the texts are more accurate, or less accurate, one might ask if the procedure texts show an improvement across the period, or a move towards using more accurate periods in the later procedure texts. Unfortunately, the answer is “not really”. Even the texts from the start of the Late Babylonian Period (such as DT 78) are already aware of the Goal-Year periods of 71 years for Jupiter, 8 years for Venus, and 59 years for Saturn. While some later texts suggest different periods, they are not an improvement over these Goal-Year periods. Mars' 47-period is also attested in the very early part of the period (in BM 45728).

Some of the early texts mention periods which then do not appear in the later texts, such as 6 years for Mercury and 15 years for Mars. Since these periods are not as accurate as the ones which are used in later texts instead, this could be viewed as an improvement in the planetary theories – that the periods ceased to be used in favour of more accurate ones. It is interesting that the 46-year Goal-Year period for Mercury does not appear in any of the early texts, and this is perhaps explained by the fact that Mercury, being small and fast-moving, is often difficult to observe. Therefore, it might take a while to determine which planetary periods truly predict its recurrence the most accurately.

It is also interesting that the 79-year period for Mars is attested in none of the pre-Seleucid texts except for TU11. This seems strange based on this chapter's earlier demonstrations that it is significantly more accurate than the 47-year period which is attested from the earliest procedure texts. However, it may be linked to the fact that the motion of Mars appeared to be less well-understood in Babylonian planetary theory than any of the other planets, perhaps because of its eccentricity and its long synodic period.<sup>192</sup> On the other hand, Jupiter (whose motion certainly *was* understood well by the Babylonian astronomers<sup>193</sup>) also has a period which is not attested in any of the early texts – the 83-year Goal-Year period.

When attempting to trace the development of non-mathematical planetary theory, another aspect to consider is how well the date corrections suggested in the procedure texts agree with calculations. Table 4.5 shows a comparison of these two types of record: the date corrections in the procedure texts from Table 4.2, and the calculated date corrections from Tables 4.3a-e and 4.4a-e. It shows whether the procedure texts and the theoretical date corrections come close to agreeing with each other.<sup>194</sup>

Note that the procedure texts do not usually specify whether the period applies to Greek-letter phenomena or Normal Star passages, so each period has been compared with each type of event. The notable exception to this is Atypical Text E, from which most of the date corrections come. In this text, each section is headed by a particular sentence, translated by Neugebauer & Sachs as “The passings by of [planet] at the Normal Stars”.<sup>195</sup> However, perhaps it was intended to refer to Greek-letter phenomena as well?

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<sup>192</sup> For discussion of this see, for example, Swerdlow (1998) pp 86-87.

<sup>193</sup> As an illustration of this, *ACT* (p. 279) lists 41 ephemerides texts for Jupiter compared with 12 for Saturn, 11 for Mercury, 9 for Venus and 8 for Mars.

<sup>194</sup> In this section I have defined “close to agreeing with each other” as up to 1 day different for Mercury and Venus, up to 2 days different for Mars and Jupiter, and up to 3 days different for Saturn (as discussed earlier in this chapter).

<sup>195</sup> Neugebauer & Sachs (1967) p. 206.

| Planet  | Record type | Period in Babylonian years | Theoretical date correction – |       | What date correction is attested in the procedure text? |                           | Do the procedure text date correction and the theoretical date correction agree? |
|---------|-------------|----------------------------|-------------------------------|-------|---|---------------------------|--|
|         |             |                            | Mean                          | Modal |   |                           |  |
| Mercury | phenomena   | 6                          | +16                           | +16   | 6yr + 10 days   | BM 45728                  | No   |
| Mercury | passages    | 6                          | +9                            | +10   | 6yr + 10 days   | BM 45728                  | Yes  |
| Mercury | phenomena   | 13                         | -3                            | -3    | 13yr - 3 days   | Atypical Text E           | Yes  |
| Mercury | passages    | 13                         | -5                            | -5    | 13yr - 3 days   | Atypical Text E           | No   |
| Mercury | phenomena   | 46                         | 0                             | -1    | 46yr - 1 day  | Atypical Text E           | Yes  |
| Mercury | passages    | 46                         | -1                            | -1    | 46yr - 1 day  | Atypical Text E           | Yes  |
| Mercury | phenomena   | 125                        | +2                            | +3    | 125yr “same day as before”                              | Atypical Text E           | No   |
| Mercury | passages    | 125                        | +3                            | +4    | 125yr “same day as before”                              | Atypical Text E           | No   |
| Venus   | phenomena   | 8                          | -4                            | -3    | 8yr - 4 days  | Atypical Text E, BM 45728 | Yes  |
| Venus   | passages    | 8                          | -2                            | -1    | 8yr - 4 days  | Atypical Text E           | No   |
| Venus   | phenomena   | 16                         | -8                            | -8    | 16yr - 2 days   | Atypical Text E           | No   |
| Venus   | passages    | 16                         | -3                            | -4    | 16yr - 2 days   | Atypical Text E           | Yes  |
| Venus   | phenomena   | 48                         | +6                            | +7    | 48yr + 2 days   | Atypical Text E           | No   |
| Venus   | passages    | 48                         | +19                           | +19   | 48yr + 2 days   | Atypical Text E           | No   |
| Venus   | phenomena   | 64                         | -1                            | -1    | 64yr + 1 or 2 days                                      | Atypical Text E           | No   |
| Venus   | passages    | 64                         | +16                           | +15   | 64yr + 1 or 2 days                                      | Atypical Text E           | No   |
| Mars    | phenomena   | 32                         | +5                            | +2    | 32yr - 5 days   | Atypical Text E           | No   |
| Mars    | passages    | 32                         | +18                           | +19   | 32yr - 5 days   | Atypical Text E           | No   |
| Mars    | phenomena   | 47                         | +2                            | +4    | 47yr + 4 days   | Atypical Text E           | Yes  |
| Mars    | phenomena   | 47                         | +2                            | +4    | 47yr + 12 days  | BM 45728                  | No   |
| Mars    | passages    | 47                         | +15                           | +14   | 47yr + 4 days   | Atypical Text E           | No   |
| Mars    | passages    | 47                         | +15                           | +14   | 47yr + 12 days  | BM 45728                  | Yes  |
| Mars    | phenomena   | 64                         | +10                           | +4    | 64yr + 4 days   | Atypical Text E           | Yes  |

| Planet  | Record type | Period in Babylonian years | Theoretical date correction – |       | What date correction is attested in the procedure text? |                           | Do the procedure text date correction and the theoretical date correction agree? |
|---------|-------------|----------------------------|-------------------------------|-------|---|---------------------------|--|
|         |             |                            | Mean                          | Modal |   |                           |  |
| Mars    | passages    | 64                         | +6                            | +9    | 64yr + 4 days   | Atypical Text E           | Yes  |
| Mars    | phenomena   | 126                        | +8                            | +10   | 126yr "same day as before"                              | Atypical Text E           | No   |
| Mars    | passages    | 126                        | -12                           | -12   | 126yr "same day as before"                              | Atypical Text E           | No   |
| Jupiter | phenomena   | 71                         | 0                             | +1    | 71yr "same day as before"                               | Atypical Text E           | Yes  |
| Jupiter | passages    | 71                         | -9                            | -3    | 71yr "same day as before"                               | Atypical Text E           | No   |
| Jupiter | phenomena   | 83                         | +17                           | +17   | 83yr - 7 days   | Atypical Text E, BM 34560 | No   |
| Jupiter | passages    | 83                         | -9                            | -7    | 83yr - 7 days   | Atypical Text E, BM 34560 | Yes  |
| Saturn  | phenomena   | 30                         | +9                            | +9    | 30yr + 9 days   | Atypical Text E           | Yes  |
| Saturn  | passages    | 30                         | doesn't work                  |       | 30yr + 9 days   | Atypical Text E           | No   |
| Saturn  | phenomena   | 59                         | -6                            | -6    | 59yr - 5 days   | BM 34560                  | Yes  |
| Saturn  | phenomena   | 59                         | -6                            | -6    | 59yr - 6 days   | Atypical Text E           | Yes  |
| Saturn  | passages    | 59                         | -10                           | -15   | 59yr - 6 days   | Atypical Text E           | No   |
| Saturn  | phenomena   | 147                        | +3                            | +3    | 147yr "same day as before"                              | Atypical Text E           | Yes  |
| Saturn  | passages    | 147                        | -7                            | +9    | 147yr "same day as before"                              | Atypical Text E           | No   |

**Table 4.5: a comparison of the theoretical date corrections and the corrections attested in the procedure texts. Each correction has been compared with theoretical date corrections of both Greek-letter phenomena and Normal Star passages. The two dates are said to agree if they are within  $\pm 1$  day of each other for Mercury and Venus,  $\pm 2$  days of each other for Mars and Jupiter, and  $\pm 3$  days of each other for Saturn.**



We see from the table that a lot of the date corrections in Atypical Text E which did not work for the Normal Star passage dates, agree very closely for the phenomena dates. Not all of the dates agree, but it seems that too many corrections are in agreement for this to be a coincidence. Perhaps the phrase which heads each planetary section does not refer to a Normal Star passage as it is used in a modern context, but is an unusual piece of terminology.<sup>196</sup>

The table shows that the theoretical date corrections and the procedure texts do *not* agree with each other most of the time. It is likely that many of these disagreements will be due to comparing Normal Star passage dates with corrections which would have been used with Greek-letter phenomena, or vice versa.

Comparing the date corrections from the procedure texts with those from calculations, we find that there are:

21 cases where the theoretical date correction and a procedure date correction disagree,  
16 cases where the theoretical date correction and a procedure text date correction agree,  
of which there are:

5 cases where the mean date correction is a better agreement with the procedure text,  
5 cases where the modal date correction is a better agreement with the procedure text,  
6 cases where they agree equally well.

From this one concludes that the Babylonian astronomers' methods for determining a date correction do not match particularly with our modern definitions of either the mean or modal value, as expected. As always, there is simply not a large enough set of data to draw any firm conclusions. However, considering the few cases where the mean and mode differ significantly (such as the 64 period for Mars' phenomena, with corrections of +10 vs. +4 days), the procedure text generally agrees more closely with the mode. Based on this, one might tentatively suggest (with the necessary warnings against ascribing modern concepts and terminology to ancient methods, as discussed above) that their methods had more in common what we would now call the mode than the mean.

#### ***4.8 A summary of the Goal-Year periods***

Table 4.6 summarises the periods used in the Goal-Year Texts, and their theoretical date corrections. The numbers in this table will be referred to again in Chapter 6.

| Planet  | Record type | Goal-Year<br>period | Date correction – |       |
|---------|-------------|---------------------|-------------------|-------|
|         |             |                     | Mean              | Modal |
| Mercury | phenomena   | 46                  | 0                 | -1    |
| Mercury | passages    | 46                  | -1                | -1    |
| Venus   | phenomena   | 8                   | -4                | -3    |
| Venus   | passages    | 8                   | -2                | -1    |
| Mars    | phenomena   | 79                  | +7                | +6    |
| Mars    | passages    | 47                  | +15               | +14   |
| Jupiter | phenomena   | 71                  | +0                | +1    |
| Jupiter | passages    | 83                  | -9                | -7    |
| Saturn  | phenomena   | 59                  | -6                | -6    |
| Saturn  | passages    | 59                  | -10               | -15   |

**Table 4.6: a summary of the theoretical date corrections to Goal-Year periods**

<sup>196</sup> The text does contain other unusual terminology, as discussed by Neugebauer & Sachs (1967), p.213.

## Chapter 5

# A comparison of the planetary data in the Goal-Year Texts, Almanacs and Normal Star Almanacs

### 5.1 Introduction

Now that we have established the theoretical date corrections for the Goal-Year periods, the next step is to investigate what corrections were used, and whether we can deduce how the Babylonian astronomers actually used them in practice. In my opinion this is closely connected to one of the other questions concerning non-mathematical astronomy which has not been conclusively answered: how were the Almanac and Normal Star Almanac planetary predictions made? As discussed in §2.8, a plausible suggestion that they were made empirically from Diary observations, via the Goal-Year Texts. However, it is clear that the data in the predictive texts is not simply an exact copy of the Goal-Year Text data, as will be discussed further below.

Hunger previously examined this problem but concluded that too little material was available for a quantitative study.<sup>197</sup> More data is available now than at the time of Hunger's analysis as more examples of the various texts become identified, dated and accessible for study. Hence, the current investigation is able to draw on records from a larger number of texts and support more firmly some conclusions relating to the questions surrounding this area.

It seems logical to consider Goal-Year Texts as an intermediate step between Diaries and the predictive texts, i.e. the Almanacs or Normal Star Almanacs. Goal-Year Texts are very easy to compile several years in advance of when they are needed, simply by taking the Diaries from the relevant years and extracting the records relating to the planet in question from each one. However, even though they are easy to produce, as a referral tool during the actual goal year they are somewhat inexact and difficult to use due to the data being written in separate sections for each planet rather than by date. Therefore, it follows from this that the next step of recopying the records into a chronological order would make them much more convenient as a tool to refer to during the goal year.

At this point we come to the matter of the date corrections, as deduced in the previous chapter. Following the above sequence of copying the planetary records:

1. Observations in Astronomical Diaries -> 2. Goal-Year Texts -> 3. Predictions in Almanacs and Normal Star Almanacs,

the date correction *could* be applied either at step 2 or step 3 in this sequence. However, recall from §2.7 that parallel records from the Diaries and the Goal-Year Texts were generally extremely similar, often identical. There was no evidence of a systematic date shift between the records in the two texts, and so, if the above sequence is correct, we must look for evidence of a date correction at step 3. In other words, we would expect to find systematic date differences when comparing the dates of parallel events in the Goal-Year Texts and in the predictive texts.

This chapter compares the planetary observations in the Goal-Year Texts with the

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<sup>197</sup> Hunger (1999).

planetary predictions in the Almanacs and Normal Star Almanacs, and compares the results with the theoretical date corrections deduced in Chapter 4, to test the theory that the predictions could have been made using the methods described above. Before directly comparing these records, there are several problems with using Goal-Year periods to predict future events that we must account for. These problems will be outlined in the following sections.

### 5.1.1 Variation of Babylonian year lengths

As described in Chapter 1, the length of the Babylonian year is not constant because there are not a whole number of lunar months in a solar year. The fact that Babylonian years could have either 12 or 13 months implies a complication in using Goal-Year periods for predictions: Goal-Year periods consist of a number of complete Babylonian years and so the exact number of months contained in any particular Goal-Year period can differ depending on how many intercalary months the Goal-Year period includes. Table 5.1 outlines the different numbers of months which the periods found in the Goal-Year Texts can contain.

| Year of cycle      | 1         | 2    | 3       | 4       | 5    | 6    |
|--------------------|-----------|------|---------|---------|------|------|
| Mercury            | 568/569   | 569  | 569     | 569     | 569  | 569  |
| Venus              | 98/99     | 99   | 99      | 99      | 99   | 99   |
| Mars (47 years)    | 581/582   | 581  | 582     | 581     | 581  | 582  |
| Mars (79 years)    | 977/978   | 977  | 977     | 977/978 | 977  | 977  |
| Jupiter (83 years) | 1026/1027 | 1026 | 1027    | 1026    | 1027 | 1027 |
| Jupiter (71 years) | 878/879   | 878  | 878     | 878     | 878  | 878  |
| Saturn             | 729/730   | 729  | 729/730 | 729     | 730  | 730  |

| Year of cycle      | 7    | 8         | 9       | 10      | 11   | 12   |
|--------------------|------|-----------|---------|---------|------|------|
| Mercury            | 569  | 569       | 568/569 | 569     | 569  | 568  |
| Venus              | 99   | 99        | 98/99   | 99      | 99   | 98   |
| Mars (47 years)    | 581  | 581       | 582     | 581/582 | 581  | 581  |
| Mars (79 years)    | 977  | 977       | 978     | 977     | 977  | 977  |
| Jupiter (83 years) | 1026 | 1026/1027 | 1027    | 1026    | 1027 | 1026 |
| Jupiter (71 years) | 878  | 878       | 879     | 878     | 878  | 878  |
| Saturn             | 729  | 730       | 730     | 730     | 730  | 729  |

| Year of cycle      | 13   | 14   | 15      | 16   | 17   | 18   | 19   |
|--------------------|------|------|---------|------|------|------|------|
| Mercury            | 569  | 569  | 569     | 569  | 569  | 569  | 569  |
| Venus              | 99   | 99   | 99      | 99   | 99   | 99   | 99   |
| Mars (47 years)    | 581  | 582  | 581     | 581  | 582  | 581  | 581  |
| Mars (79 years)    | 977  | 977  | 977     | 977  | 977  | 977  | 977  |
| Jupiter (83 years) | 1026 | 1027 | 1026    | 1027 | 1027 | 1026 | 1027 |
| Jupiter (71 years) | 878  | 878  | 878/879 | 878  | 879  | 878  | 878  |
| Saturn             | 730  | 730  | 729     | 730  | 730  | 729  | 730  |

**Table 5.1: the number of months in the whole number of Babylonian years used for the Goal-Year periods, for each year in the 19-year Metonic cycle. Year 1 of the cycle contains the Month VI<sub>2</sub>. The different number of months in different periods is due to the distribution of intercalary months. Note that in some years the number of months can be one of two values, caused by the Month VI<sub>2</sub> halfway through the year.**

For example, we know that an 8-year Goal-Year period was used for Venus' events.

Referring to this table, we see that an 8-year period would contain either 98 or 99 months, depending on which year within the cycle the observations came from. The actual period of Venus' motion, as seen in the previous chapter, is 99 lunar months. This means that for most years the Venus observations can be used to predict events which will happen in exactly the same month of the year 8 years later.

However, for part of some of the years there are only 98 intervening months in the Goal-Year period rather than 99. Following the method of counting forward exactly 8 Babylonian years would lead to predictions of Venus' Greek-letter phenomena for one month later than they will actually occur during the goal year itself. A correction of one month will need to be applied to the data in the years where this is the case.

Clearly, knowing when an extra month would need to be added or subtracted is absolutely crucial for the success of Goal-Year methods of prediction. There is evidence that the Babylonian astronomers were aware of this problem and accounted for it, which is the focus of the following chapter.

### 5.1.2 Normal Star passages around stationary points

Goal-Year periods generally provide a good approximation for predicting recurring planetary events. However, these patterns of Normal Star passage dates vary greatly as the planet nears a stationary point and its motion becomes less regular. A planet's longitude and latitude around the time of a stationary point during any particular year will not follow exactly the same path as its longitude and latitude around a stationary point one Goal-Year period later. This means that occasionally a passage of a planet by a Normal Star will be observed one year that will then not occur a Goal-Year period later or, equally, that a planet could reach a Normal Star in longitude one year where it had not done so a Goal-Year period previously, due to the longitude at which it became stationary.

An example of this is illustrated in Figure 5.1, which shows the longitude of Venus throughout two Babylonian years one Goal-Year period (8 years) apart. The longitude values have been calculated using JPL's Horizons ephemerides.

The figure displays Venus' longitude throughout the two years and marks the days on which it reaches each of the commonly used Normal Stars. The stars which Venus passed during its period of invisibility are shown in italics. The figure demonstrates that, from about day 100 of the years onwards, the Goal-Year period of 8 years is an excellent fit for Venus' motion. Note that Venus consistently reaches each Normal Star in longitude one or two days earlier in SE 112 than in SE 120, as we would expect from the date corrections in Chapter 4. However, before day 100 there is much less agreement between the two years concerning the dates when Venus passes by the stars, due to the irregular motion around the stationary points. Highlighted in the figure are two stars which Venus would have reached in longitude during one year but not during the other –  $\gamma$  Geminorum in SE 112 and  $\beta$  Tauri in SE 120.

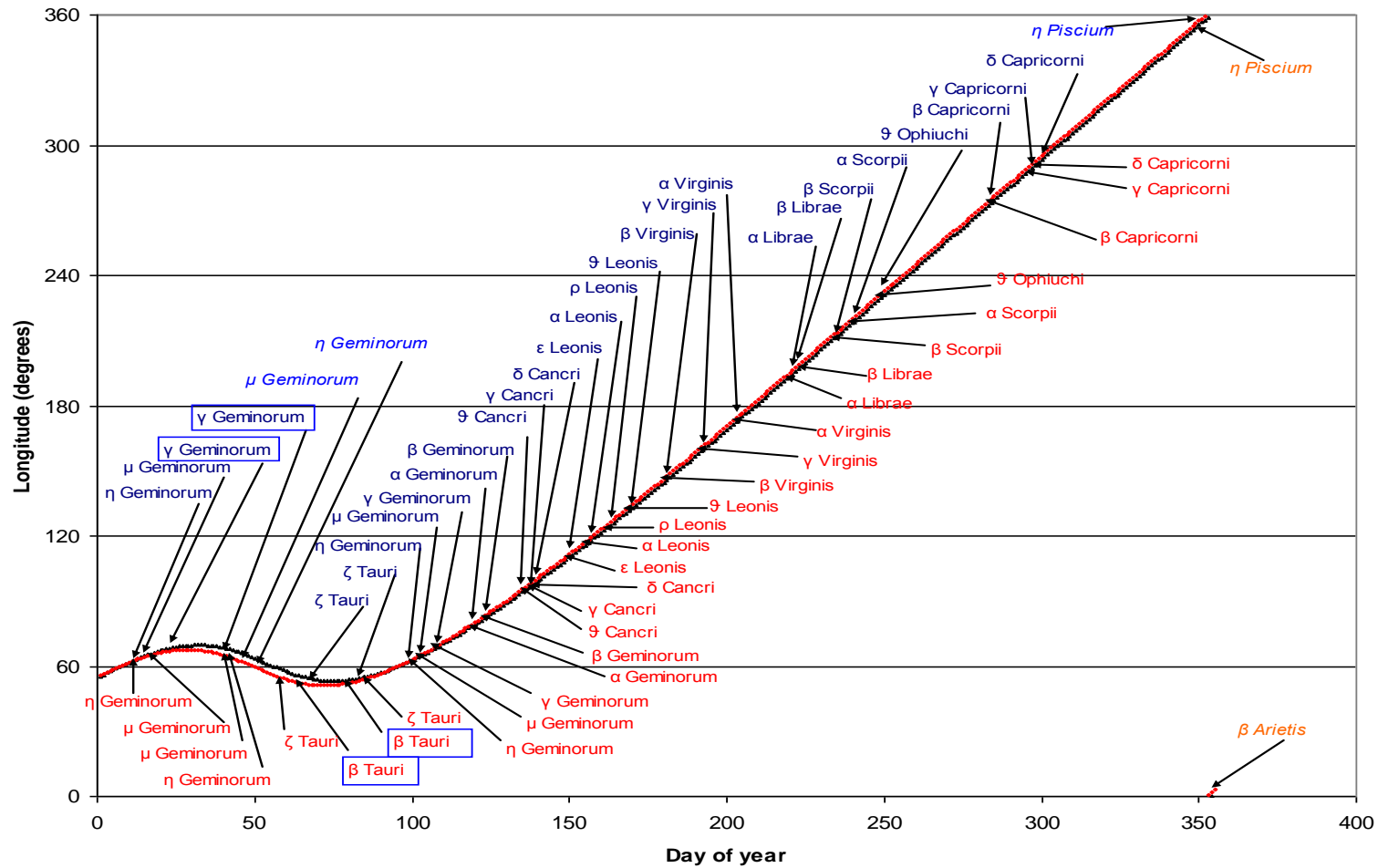


Figure 5.1: Venus' longitude during the Babylonian years SE 112 and SE 120, marking the points where the planet passed by each Normal Star. Star names in *italics* were passed during Venus' periods of invisibility. The boxes around *γ Geminorum* and *β Tauri* highlight stars which the planet moved past in one year but not the other, showing that these planetary passages presumably could not have been predicted using Goal-Year methods.

This shows that predicting events using Goal-Year methods could lead to occasional planet-Normal Star passages being predicted that would not actually happen during a particular year, or passages failing to be predicted because they did not occur one Goal-Year period previously. It is likely that this would have been an extremely rare event, because it requires a quite specific set of circumstances – the planet’s motion would need to reach its stationary point at about the same longitude as a Normal Star; and the equivalent stationary point a Goal-Year period earlier or later would have to occur at a longitude different enough that it clearly did *not* pass the same Normal Star. Nevertheless, the question remains unanswered whether the Babylonian astronomers were aware of this and accounted for it.

### 5.1.3 Accuracy of the Goal-Year periods in terms of date and latitude

As shown in the previous chapter, planetary events will tend to reoccur a particular number of days earlier or later in the year after a Goal-Year period has passed. It is hoped that a comparison of the dates of records of the same event in the Goal-Year texts and the predictive texts will show date differences consistent with the theoretical date corrections which were summarised in Table 4.6.

The previous chapter also showed that the latitude changes across the Goal-Year periods were almost always negligible, or, in other words, that the distance between a planet and star at the time of a planetary passage would generally be the same for the equivalent planetary passage a Goal-Year period later. Therefore, we would expect to find that Goal-Year records and predictive records of the same planetary passages refer to the same planet-star distance. Figure 5.2 summarises these latitude differences by showing the Goal-Year ‘Texts’ planetary periods from Figures 4.1a-e.

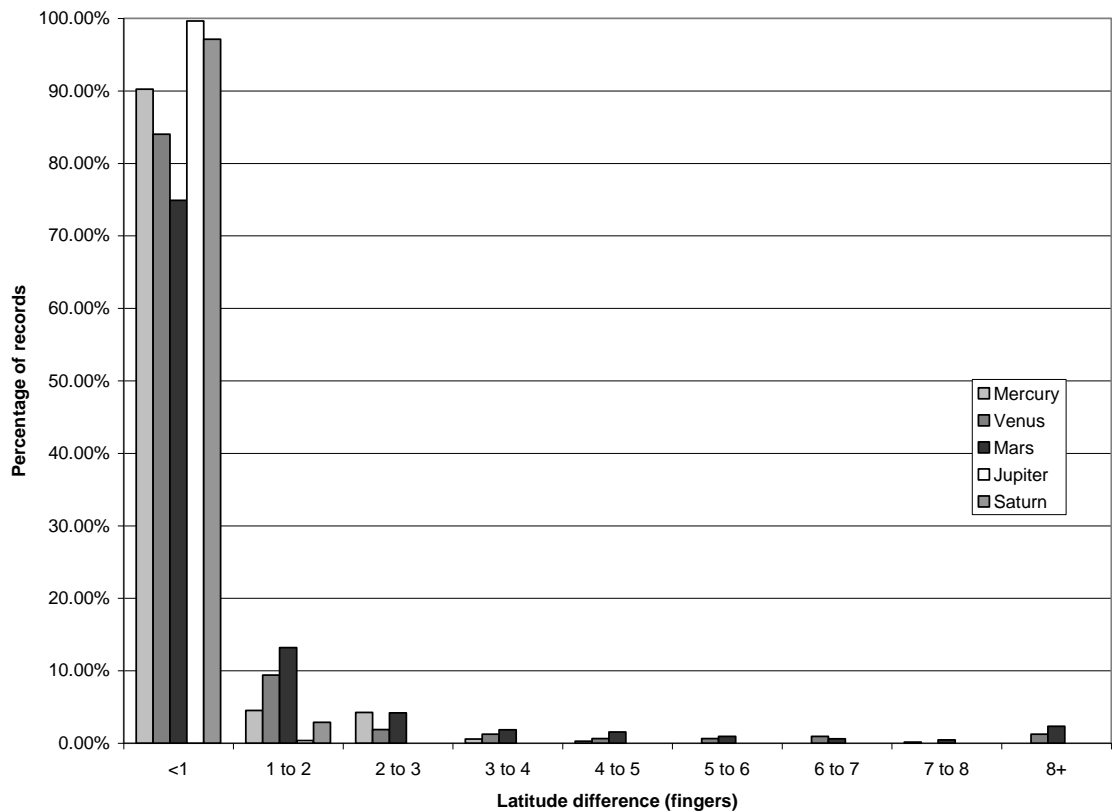


Figure 5.2: a summary of the theoretical latitude differences between two corresponding planetary passages one Goal-Year period apart.

## 5.2 A comparison of the planetary records in Almanacs, Normal Star Almanacs, and Goal-Year Texts

### 5.2.1 The database

For this investigation, all the Goal-Year Texts, Almanacs and Normal Star Almanacs were examined to find cases where the same planetary event is mentioned in at least two of these text types. Goal-Year Text records were compared with predictive texts for the same year as the goal year, i.e. in this context the Goal-Year Text records were treated as data to be used for making predictions in the goal year, rather than records from the observational years.

The full database can be found in Appendices F and G. Appendix F shows all examples of matching planetary predictions found both in Normal Star Almanacs and in Almanacs, in order to show whether we need to consider the data from these two sources separately.

As always, small data sets make it more problematic to draw firm conclusions. While, as Tables 2.7 and 2.8 demonstrated, there are extant Almanacs for 51 different years and Normal Star Almanacs for 63 different years, only 14 of these years overlap and in only 5 years are there actually corresponding examples of the same planetary record. Thus, the total remaining comparison of Normal Star Almanac and Almanac data is 27 pairs of planetary events. They show that there are no significant differences between records found in the two texts: in 22 of these cases the records are identical, as far as the text is preserved.

Of the five cases where the records differ, three are most likely examples of copying errors on the part of either the original scribe or a modern copyist. The reasoning behind this is explained below for each case:

8 AN *ina* RÍN IGI  
“The 8th, Mars’ first appearance in Libra.”  
(LBAT \*\*1059, Rev. 1 (Normal Star Almanac for SE 201))

8 AN *ina* A IGI  
“The 8th, Mars’ first appearance in Leo’.”  
(LBAT 1151, Obv. 14 (Almanac for SE 201))

The cuneiform signs for Leo and Libra are quite similar. Calculating the longitude of Mars on this date shows that it was at a longitude of around 182°, i.e. in the zodiacal sign of Libra.

2 GENNA *ina* SAG RÍN UŠ  
“The 2nd, Saturn stationary in the beginning of Libra.”  
(LBAT \*\*1059, Rev. 25 (Normal Star Almanac for SE 201))

20 GENNA *ina* SAG RÍN ‘x’.  
“The 20th, Saturn ‘x’ in the beginning of Libra.”  
(LBAT 1151, Rev. 8 (Almanac for SE 201))

It is very likely that in the record from the Almanac the date should have been the 2<sup>nd</sup>. The record is at the beginning of a month and is followed by several records earlier than day 20 of the month, suggesting that the 20th is the wrong date.

29 GU<sub>4</sub>-UD *ina* ŠÚ *ina* HUN IGI

“The 29th, Mercury’s first appearance in the west in Aries.”  
(LBAT \*\*1059, Rev. 35 (Normal Star Almanac for SE 201))

29 GU<sub>4</sub>-UD *ina* 'ŠÚ *ina* HUN ŠÚ'

“The 29th, Mercury’s ‘last (sic) appearance in the west in Aries’”  
(LBAT 1151, Rev. 12 (Almanac for SE 201))

It is clear from reading the other Mercury records in the Almanac that it contains a scribal error and “first appearance” in this case.

The remaining two records that differ are, in one case, a slightly different use of terminology, and in the one remaining case a disagreement on the date of a planetary event.

21 *dele-bat ina* NIM *ina* SAG HUN IGI

“The 21st, Venus’ first appearance in the east in the beginning of Aries.”  
(LBAT 1005, Rev. 3’ (Normal Star Almanac for SE 92))

21 *dele-bat ina* NIM *ina* HUN IGI

“The 21st, Venus’ first appearance in the east in Aries.”  
(LBAT \*1118-9, Rev. 11 (Almanac for SE 92))

5 *dele-bat ina* NIM *ina* PA IGI

“The 5th, Venus’ first appearance in the east in Sagittarius.”  
(LBAT \*\*1059, Rev. 13 (Normal Star Almanac for SE 201))

6 *dele-bat ina* NIM [*ina* x IGI ...]

“The 6th, Venus’ [first appearance] in the east [in x ...]”  
(LBAT 1151, Rev. 3 (Almanac for SE 201))

Given that writing an Almanac or Normal Star Almanac involves copying and recopying records several times, an occasional copying error is inevitable (especially once we allow for errors in modern copying and translations as well). Discrepancies in date may also result from events being recorded differently in parallel Diaries, as was discussed in Chapter 2.

5 differences out of 28 may seem to be more than an ‘occasional’ copying error, but four of these errors are from the same Almanac and this could therefore be viewed as an isolated example of a particularly badly copied tablet. Otherwise, the number of discrepancies in the dataset is not significant.

Only one out of the 28 examples shows any disagreement in the predicted *date* of an event (which is what this investigation is interested in), and one can therefore reasonably conclude that any date corrections that were applied to predictions in the Normal Star Almanacs were applied equally to the Almanacs. Consequently, the subsequent sections of this investigation does not examine the Normal Star Almanac data differently from the Almanac data, but treat the records which they have in common (i.e. dates of Greek-letter phenomena) as one dataset.

Appendix G contains all extant examples of an equivalent record existing in both a Goal-



Year Text and an Almanac or Normal Star Almanac.<sup>198</sup> The records did not need to be complete and unbroken to be included in the database, as long as each record of the pair contained either an unbroken date or measurement of a planet-Normal Star distance for comparison.

In the appendices, the translations have been slightly abbreviated for reasons of space. For example, remarks from the Goal-Year Texts on a planet's size or brightness at its first appearance, or time measurements around a planet's first or last appearance, have not been included. However, dates of "ideal" first appearances and "last seen" dates around the times of last appearances have been included; there is further discussion of this later. Below are some examples of typical record pairs from the database.

[IZI ...] 'GE<sub>6</sub> 10' *ina* ZALÁG *dele-bat e* LUGAL 3 SI  
 "[Month V...] 'Night of the 10th,' last part of the night, Venus was 3  
 fingers above  $\alpha$  Leonis."  
 (ADART Vol. VI no. 15, Obv. 13 (Goal-Year Text for SE 106))

[IZI ...] GE<sub>6</sub> 8 *ina* ZALÁG *dele-bat e* LUGAL 3 SI  
 "[Month V...] Night of the 8th, last part of the night, Venus was 3  
 fingers above  $\alpha$  Leonis."  
 (LBAT \*1013, Obv. 8' (Normal Star Almanac for SE 106))

We can compare both the date and measurement in this pair of records.

APIN GE<sub>6</sub> 16<sup>2</sup> USAN AN SIG SI MÁŠ 2 KÙŠ  
 "Month VIII, night of the 16<sup>th</sup>, first part of the night, Mars was 2  
 cubits below  $\beta$  Capricorni."  
 (ADART Vol. VI no. 69, Rev. 2 (Goal-Year Text for SE 194))

GAN ... 'GE<sub>6</sub>' 2 USAN AN SIG SI MÁŠ [...]  
 "Month IX ... 'Night of the' 2nd first part of the night, Mars was  
 below  $\beta$  Capricorni [...]"  
 (LBAT 1057, Rev. 2' (Normal Star Almanac for SE 194))

Here the date is available for comparison, though the distance measurement has been lost.

'AB 20 MÚL<sup>2</sup>-BABBAR<sup>2</sup> [*ana* ME E-a ...]  
 "'Month X, the 20th, Jupiter's<sup>2</sup> [*acronychal rising* ...]"  
 (ADART Vol. VI no. 17, Obv. 1' (Goal-Year Text for SE 107))

[AB...] 20 MÚL-BABBAR '*ana* ME E-a'  
 "[Month X...] The 20th, Jupiter's '*acronychal rising*.'"  
 (LBAT 1016, Rev. 3' (Normal Star Almanac for SE 107))

Again, the dates can be compared.

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<sup>198</sup> Recall that "equivalent" here refers to comparing Goal-Year Text records with predictive texts which cover the same Babylonian year as the goal year.

IZI 24 GU<sub>4</sub>-UD *ina* NIM *ina* A IGI KUR NIM-*a* 16,40 *na-su in* 21 IGI  
 “Month V, the 24th, Mercury’s first appearance in the east in Leo; it  
 was bright (and) high, rising of Mercury to sunrise: 16°40’; (ideal) first  
 appearance on the 21st.”  
 (ADART Vol. VI no. 86, Obv. 22 (Goal-Year Text for SE 236))

‘TZI’ ... 21 GU<sub>4</sub>-UD *ina* NIM *ina* A IGI  
 “Month V’ ... The 21st, Mercury in the east in Leo first visibility.”  
 (LBAT 1174, Obv. 10 (Almanac for SE 236))

In this case, we can compare the predicted date from the Almanac with either the observed or the ideal date from the Goal-Year Text. 26 of the Greek-letter phenomena records taken from the Goal-Year Texts include either a second (ideal) date for first visibilities as above, or the phrase “from the x<sup>th</sup> when I watched I did not see it” in the case of last visibilities.

Note that in some cases found in the Appendix the two records are clearly predicting the same events, but the date differs by a month. This is to be expected, as was previously outlined in §5.1. These “month shifts” have been ignored in this chapter, where we are only interested in the date differences of events; how the month shifts and other calendrical issues might have been dealt with is the focus of Chapter 6.

For reference, the database contains the following number of matching pairs of records:

84 examples of overlapping Normal Star passage predictions from the Goal-Year Texts and Normal Star Almanacs;  
 Mercury 13    Venus 37    Mars 27    Jupiter 4    Saturn 3 records.

39 examples of overlapping Greek-letter phenomenon predictions from the Goal-Year Texts and Normal Star Almanacs;  
 Mercury 20    Venus 3    Mars 2    Jupiter 5    Saturn 9 records.

42 examples of overlapping Greek-letter phenomenon predictions from the Goal-Year Texts and Almanacs;  
 Mercury 24    Venus 3    Mars 5    Jupiter 3    Saturn 7 records.

In total, allowing for partially broken records, this leaves us with the following numbers of record pairs to analyse:

64 records which can be used for comparing recorded planet – Normal Star distances.  
 53 records which can be used for comparing recorded dates of planet – Normal Star passages.  
 81 records which can be used for comparing dates of Greek-letter phenomena.

Of the Greek-letter phenomenon records in the database, only a few included an ideal or “last seen” date:

Number of records with both an observed and ideal or “last seen” date: 18 (14 for Mercury, 2 for Venus, 2 for Saturn)  
 Number of records with an ideal or “last seen” date only: 7 (4 for Mercury, 1 for Jupiter, 2 for Saturn)

### 5.2.2 Predicted distances of Normal Star passages across the Goal-Year periods

As demonstrated in Chapter 4, the theoretical analysis implies that Normal Star passages in the Normal Star Almanacs and the Goal-Year Texts should record very similar distances for the same events. Table 5.2 summarises the results of this comparison between the texts and shows that, broadly, the results from the Babylonian texts agree with the theoretical results. In most (75%) of the remaining pairs of records, the distance measurements exactly match each other, adding strong support to the theory that Normal Star Almanac predictions are from the same source as the Goal-Year Text records.

| Planet  | Number of cases where the distance measurement: |                  |                |
|---------|---|------------------|----------------|
|         | Matches   | “Nearly” matches | Does not match |
| Mercury | 6   | 2                | 1              |
| Venus   | 23  | 5                | 4              |
| Mars    | 15  | 1                | 2              |
| Jupiter | 2   | 1                | 0              |
| Saturn  | 2   | 0                | 0              |
| All     | 48  | 9                | 7              |

**Table 5.2:** A comparison of the preserved distance measurements in records of Normal Star passages found in both the Goal-Year Texts and the Normal Star Almanacs, showing when the distance recorded in the two texts agreed or disagreed.

Of the record pairs where the recorded distances are not an exact match, 14% are classed as “nearly” matching and only 11% are classed as being notably different from each other. I shall now examine the non-matching records in more detail.

The nine cases of measurement pairs which have been classed as “near” matches are shown in Table 5.3. “Nearly” matching records include measurements that differed from each other by  $\frac{1}{2}$  a cubit or less, or up to a cubit apart where one of the readings is marked as uncertain. The seven cases of measurement pairs which are classed as being clearly “different” from each other are shown in Table 5.4; “different” measurements include those where the two texts differ from each other by a cubit or more.

|         | Year   | Normal Star Almanac record | Goal-Year Text record            |
|---------|--------|----------------------------|----------------------------------|
| Mercury | SE 96  | 1 $\frac{2}{3}$ cubits     | 1 $\frac{5}{6}$ cubits           |
|         | SE 194 | 1 'cubit x' fingers        | 1 cubit 4 fingers                |
| Venus   | SE 107 | 4 cubits                   | 5 <sup>2</sup> cubits            |
|         | SE 107 | 1 cubit 8 fingers          | 1 cubit 10 fingers               |
|         | SE 192 | $\frac{2}{3}$ cubit        | $\frac{1}{3}$ <sup>2</sup> cubit |
|         | SE 194 | '4 <sup>n</sup> [...]      | 5 cubits                         |
|         | SE 194 | 3 cubits                   | 2 <sup>2</sup> cubits            |
| Mars    | SE 96  | 3 cubits                   | 2 $\frac{1}{2}$ cubits           |
| Jupiter | SE 184 | 2 $\frac{1}{2}$ cu[bits]   | 2 cubits                         |

**Table 5.3:** Details of the Normal Star passage distances from Table 5.2 where the measurement

"nearly" agreed.

| Planet  | Year   | Normal Star Almanac<br>record | Goal-Year Text record | Notes                |
|---------|--------|-------------------------------|-----------------------|----------------------|
| Mercury | SE 201 | 4 cubits                      | 1 cubit               | GYT SE 155: 4 cubits |
| Venus   | SE 96  | 3 cubits                      | 2 cubits              |                      |
|         | SE 96  | 1 1/3 cubits                  | 2 1/2 cubits          |                      |
|         | SE 107 | 2 cubits                      | 1/2 cubit             |                      |
|         | SE 194 | 3 cubits                      | 5 cubits              | GYT SE 186: 3 cubits |
| Mars    | SE 107 | 3 1/2 cubits                  | 2 [cubits]            |                      |
|         | SE 194 | 2 cubits                      | 1 cubit               |                      |

**Table 5.4: Details of the Normal Star passage distances from Table 5.2 where the measurement disagreed. Where possible, the distance measurement from a previous text has also been given for comparison.**

A possible explanation for records which “nearly” match is that the measurements may have been copied from different Astronomical Diaries for the same year. As discussed in Chapter 2, a few examples remain of two Diaries which cover the same month and which have recorded a measurement or a date slightly differently. Recall that Tables 2.3, 2.4 and 2.5 gave details of these matching records and showed that (for records of the same event on the same date) a difference of opinion regarding a distance measurement, up to a difference of around half a cubit, is quite common. I therefore took a half a cubit to be the division between measurements which “nearly” matched and those which were “different”, which allowed for a clear division between the two categories. I suggest that a straightforward way to account for a pair of records which “nearly” match is the situation where the Goal-Year Text had been copied from one Diary, and the Normal Star Almanac had been created using records copied from an alternate Diary.

Another explanation for records in either the “nearly” agreeing or the “different” categories is, as discussed above, that they may be due to copying errors. It can be tempting to ascribe all Babylonian records which do not fit our expectations to “scribal error”, but this is generally unhelpful at best. Nevertheless, there are many cases where the wrong sign or number has been included in a text and clearly another one was intended. For example, Table 5.4 also shows the two cases where the comparison seemed to be “different” or not agree in the two texts for the same year, but when the Goal-Year Text from one Goal-Year period further back *did* agree with the Normal Star Almanac.

At first one might assume that a differing pair of records was an indication of an inaccurate prediction, or an argument against our theory that the two texts’ records are derived from the same source. However, in these two comparisons this is demonstrably *not* the case, as the Normal Star Almanac prediction ultimately agrees with observation. Instead, this is almost certainly a straightforward example of a copying error in the Goal-Year Text. However, one must be wary of extrapolating this explanation to *all* of the “different” measurement pairs.

### 5.2.3 Predicted date corrections of Normal Star passages across the Goal-

## Year periods

Table 5.5 summarises the date differences for the data relating to NS passages. For each pair of equivalent records the table shows the calculated differences between the given dates, and the number of records which show each correction. For example, a correction of “-2” means that the date of the Normal Star Almanac record is 2 days earlier in the month than the Goal-Year Text’s record of the same event.

|         |                             |     |    |    |   |
|---------|-----------------------------|-----|----|----|---|
| Mercury | Correction applied, in days | -1  | 0  | 1  |   |
|         | Number of records           | 8   | 2  | 1  |   |
| Venus   | Correction applied, in days | -3  | -2 | -1 | 1 |
|         | Number of records           | 2   | 11 | 10 | 1 |
| Mars    | Correction applied, in days | 15  | 16 | 17 |   |
|         | Number of records           | 2   | 12 | 2  |   |
| Jupiter | Correction applied, in days | -7  |    |    |   |
|         | Number of records           | 1   |    |    |   |
| Saturn  | Correction applied, in days | -22 |    |    |   |
|         | Number of records           | 1   |    |    |   |

**Table 5.5: The differences between dates of events, when comparing equivalent Normal Star passage records in the Goal-Year Texts and Normal Star Almanacs.**

As is so often the case in these investigations, a problem with analysing these records is the extremely small amount of remaining data. For Mercury, Venus and Mars we can infer date corrections from the comparisons, analogous to those produced from the theoretical data in the previous chapter. However, there is only one remaining pair of records for Jupiter or Saturn and so we cannot draw any conclusions for the date corrections applied to these planets.

Table 5.6 summarises the modal date corrections that the records indicate that the Babylonian astronomers used for planetary passages. The modal corrections suggested by the theoretical data from Chapter 4 are also shown, along with the percentage of the records which fall within  $\pm$  one day of the peak value in each case.

|         | Date corrections using calculations<br>from Chapter 4 |   | Date corrections using Normal Star passage<br>records from Babylonian texts |                        |   |
|---------|---|---|---|------------------------|---|
|         | Modal date<br>difference in<br>days                   | Percentage<br>within $\pm$ 1 day<br>of peak value | Modal date<br>difference in<br>days   | Total no of<br>records | Percentage within<br>$\pm$ 1 day of peak<br>value |
| Mercury | -1  | 99%   | -1  | 11                     | 91%   |
| Venus   | -1  | 92%   | -2  | 24                     | 96%   |
| Mars    | +14   | 78%   | +16   | 16                     | 100%  |
| Jupiter | -7  | 55%   | -7  | 1                      | 100%  |
| Saturn  | -15   | 32%   | -22   | 1                      | 100%  |

**Table 5.6: A summary of planetary passage date corrections: a comparison of expected date corrections from Chapter 4’s theoretical analysis and date corrections from Babylonian records of Normal Star passages.**

The table demonstrates that, for Mercury and Venus, the Babylonian records imply the use of date corrections very close to those expected from the theoretical data. The theoretical

data showed that using a date correction of -1 day for Mercury or Venus would predict the correct date of a planetary passage over 90% of the time, and the Babylonian records bear out this theory. While Venus' modal correction from the Babylonian records is -2 days rather than -1 day, the difference is very small: eleven records in Table 5.5 show a difference of -2 days compared with ten showing a difference of -1 day.

For Mars, the date difference between records in the two texts is very consistently 16 days. This does not completely agree with the theoretical data, which suggested a modal correction of 14 days, suggesting that if the Babylonian astronomers were using a correction of 16 days they would often have been expecting to view the planetary passage a day or two after the passage theoretically took place. Calculations show that over the course of one day Mars' longitude changes by an average of  $0.51^\circ$ , with a standard deviation of  $0.32^\circ$ , meaning that most of the time Mars would have moved  $1^\circ$  or so of longitude between the theoretical passage date and the expected Babylonian passage date. Given the uncertainty in determining at exactly what point a planet is said to have passed by a Normal Star (see Chapter 3), a longitude difference of  $1^\circ$  or less suggests that the date correction used in the Normal Star Almanacs would still be a good approximation for predicting Mars' Normal Star passages.

Again, no firm conclusions can be drawn from the extremely small amount of data remaining for Jupiter and Saturn.

The corrected periods used for predicting planetary passages should also be applicable to dates when a planet changes zodiacal sign. However, these dates are recorded in very few Goal-Year Texts (*ADART* Vol. VI Nos. 77, 86, 90 and 91 only), suggesting that they were not explicitly predicted in the same way as dates of Greek-letter phenomena were, but perhaps deduced using dates of passing nearby Normal Stars.<sup>199</sup>

Observations and predictions of sign entry dates can be found in the Diaries and the Almanacs respectively. Comparing dates when a planet is observed moving into a particular zodiacal sign in one year, with predicted dates of the planet moving into the same sign exactly one Goal Year period later, should show the same date corrections as Table 5.6. Very few such comparisons are available from the remaining data; no statistical analysis can be made of these record pairs but for completeness they have been included in Table 5.7.

| Text         |            | Date (year SE) |                 |    | Date difference | Planet  | Zodiacal sign reached |
|--------------|------------|----------------|-----------------|----|-----------------|---------|-----------------------|
| Diary -178 C | 'Rev. 16'  | 133            | XII             | 4  |                 |         |                       |
| LBAT 1135    | Rev. 4     | 179            | XII             | 8  | +4              | Mercury | Pisces                |
| Diary -118 B | UE 1       | 193            | VII             | 3  |                 |         |                       |
| LBAT 1151    | Obv. 14    | 201            | VII             | 1  | -2              | Venus   | Sagittarius           |
| Diary -83    | 'Obv.' 20' | 228            | III             | 23 |                 |         |                       |
| LBAT 1174    | Obv. 6     | 236            | III             | 21 | -2              | Venus   | Leo                   |
| Diary -122 B | 'Obv.' 10' | 189            | II              | 7  |                 |         |                       |
| LBAT 1174    | Obv. 1     | 236            | I               | 26 | -11             | Mars    | Aries                 |
| Diary -122 D | 'Rev.' 8'  | 189            | VI <sub>2</sub> | 8  |                 |         |                       |
| LBAT 1174    | Obv. 12    | 236            | VI              | 29 | -9              | Mars    | Cancer                |

<sup>199</sup> See the discussion of these issues in §3.3; also Huber (1958), Jones (2004), Steele & Gray (2007).

|              |          |     |    |    |     |  |        |         |  |  |  |  |
|--------------|----------|-----|----|----|-----|--|--------|---------|--|--|--|--|
| Diary -136 A | 'Obv. 6' | 175 | VI | 30 |     |  |        |         |  |  |  |  |
| LBAT 1164-5  | Obv. 12  | 234 | V  | 30 | -30 |  | Saturn | Scorpio |  |  |  |  |

**Table 5.7: A comparison of the dates of observations of a planet changing zodiacal signs from the Astronomical Diaries, with predictions of the same event from an Almanac for one Goal-Year period later.**

#### 5.2.4 Predicted date corrections of Greek-letter phenomena across the Goal-Year periods

Table 5.8 summarises the date differences for the data relating to Greek-letter phenomena. As was the case with Table 5.5, the table shows the calculated differences between the recorded dates of each pair of equivalent records in the Goal-Year Texts and Almanacs or Normal Star Almanacs, and the number of records which show each correction.

Table 5.9 shows data from the same planetary records as Table 5.8, and also includes comparisons of ideal dates of first visibilities or “last seen” dates of last visibilities when these have been recorded. For the present analysis, this means that planetary visibility phenomena for which only an ideal or “last seen” date remained in the Goal-Year Text will only appear in Table 5.9, and phenomena for which only an observed date remained will appear in both Tables 5.8 and 5.9. For phenomena where the Goal-Year text had *both* an observed and an ideal or “last seen” date, the difference involving the observed date is shown in Table 5.8, and the difference involving the ideal or “last seen” date in Table 5.9.

|         |                             |     |     |    |    |    |    |    |    |    |   |    |
|---------|-----------------------------|-----|-----|----|----|----|----|----|----|----|---|----|
| Mercury | Correction applied, in days | -7  | -5  | -4 | -3 | -2 | -1 | 0  | 1  | 4  | 7 | 10 |
|         | Number of records           | 1   | 3   | 1  | 3  | 7  | 4  | 11 | 2  | 1  | 1 | 2  |
| Venus   | Correction applied, in days | -7  | -6  | -5 | -4 |    |    |    |    |    |   |    |
|         | Number of records           | 1   | 1   | 1  | 3  |    |    |    |    |    |   |    |
| Mars    | Correction applied, in days | -6  | 0   | 4  | 8  | 9  | 17 |    |    |    |   |    |
|         | Number of records           | 1   | 2   | 1  | 1  | 1  | 1  |    |    |    |   |    |
| Jupiter | Correction applied, in days | -2  | -1  | 0  | 1  |    |    |    |    |    |   |    |
|         | Number of records           | 1   | 2   | 3  | 1  |    |    |    |    |    |   |    |
| Saturn  | Correction applied, in days | -13 | -12 | -7 | -6 | -5 | 18 | 22 | 24 | 28 |   |    |
|         | Number of records           | 1   | 1   | 3  | 1  | 2  | 1  | 1  | 2  | 1  |   |    |

**Table 5.8: The differences between dates of events, when comparing equivalent records of Greek-letter phenomena in the Goal-Year Texts and Normal Star Almanacs or Almanacs.**

|         |                             |    |    |    |    |    |    |   |   |   |   |    |
|---------|-----------------------------|----|----|----|----|----|----|---|---|---|---|----|
| Mercury | Correction applied, in days | -7 | -4 | -3 | -2 | -1 | 0  | 1 | 3 | 4 | 7 | 10 |
|         | Number of records           | 1  | 1  | 3  | 3  | 4  | 22 | 3 | 1 | 1 | 1 | 2  |
| Venus   | Correction applied, in days | -5 | -4 |    |    |    |    |   |   |   |   |    |
|         | Number of records           | 1  | 5  |    |    |    |    |   |   |   |   |    |
| Mars    | Correction applied, in days | -6 | 0  | 4  | 8  | 9  | 17 |   |   |   |   |    |
|         | Number of records           | 1  | 2  | 1  | 1  | 1  | 1  |   |   |   |   |    |
| Jupiter | Correction applied, in days | -2 | -1 | 0  | 1  |    |    |   |   |   |   |    |
|         | Number of records           | 1  | 2  | 3  | 2  |    |    |   |   |   |   |    |

|        |                             |     |     |    |    |    |    |    |    |    |    |
|--------|-----------------------------|-----|-----|----|----|----|----|----|----|----|----|
| Saturn | Correction applied, in days | -17 | -10 | -9 | -7 | -6 | -5 | 18 | 22 | 24 | 28 |
|        | Number of records           | 2   | 1   | 1  | 3  | 1  | 2  | 1  | 1  | 2  | 1  |

**Table 5.9: The differences between dates of events, when comparing equivalent records of Greek-letter phenomena in the Goal-Year Texts and Normal Star Almanacs or Almanacs, as Table 5.8 but including “ideal” dates and “last seen” dates when available.**

As we saw for the planetary passage data, the small amounts of available data mean that it is not easy to draw firm conclusions from the results. This is particularly apparent for Mars and Saturn, where the spread of date corrections shows no clear peak. For Mercury, there is both a clear peak correction and a very wide spread of data, due to the fact that there are a lot more extant Mercury records than for any of the other planets. Venus and Jupiter demonstrate a much more consistent correction but only from a small number of available record comparisons.

Contrasting Tables 5.8 and 5.9 also gives us an idea of how the ideal dates found in the Goal-Year Texts could have been used in practice. Again, there is only really enough data for this to become apparent in the case of Mercury. In both tables, Mercury’s modal correction to dates of Greek-letter phenomena is at  $\pm 0$  days, but the number of records showing this correction is significantly higher when we take into account the ideal dates of events. This leads to the conclusion that ideal dates must have been an important part of compiling the predictive texts.

Table 5.10 summarises the most common date corrections which the records indicate that the Babylonian astronomers were using for Greek-letter phenomena. In the same way as Table 5.6, the modal corrections from Chapter 4’s theoretical calculations are again shown, along with the percentage of the records which fall within  $\pm$  one day of the modal value.

Examining the percentages of results which fall close to the modal value provides an interesting contrast between Table 5.10 and Table 5.6. Table 5.6 showed that, for any particular planet’s Normal Star passages, the date corrections applied were nearly always the same, to a high degree of consistency. However, here we see that there is a much wider spread of the data for Greek-letter phenomena. This means that, even though the modal corrections for Babylonian dates of Greek-letter phenomena generally match the expected theoretical values, the data show a much lower consistency in the date corrections. This is despite the fact that in Chapter 4 it was shown that the theoretical date corrections were much more consistent (in terms of percentage of records falling close to the modal date correction) for dates of Greek-letter phenomena than Normal Star passages.

|         | Date corrections using calculations<br>from Chapter 4 |   | Date corrections using Greek-letter phenomena<br>records from Babylonian texts |                        |   |
|---------|---|---|--|------------------------|---|
|         | Modal date<br>difference,<br>in days                  | Percentage within<br>$\pm 1$ day of peak<br>value | Modal date<br>difference,<br>in days   | Total no of<br>records | Percentage within<br>$\pm 1$ day of peak<br>value |
| Mercury | -1  | 99%   | 0  | 36                     | 47%   |
|         |   |   |  | 42                     | (69% using ideal<br>dates)                        |
| Venus   | -3  | 99%   | -4   | 6                      | 67%   |
|         |   |   |  | 6                      | (100% using ideal<br>dates)                       |
| Mars    | +6  | 82%   | 0  | 7                      | 29%   |
| Jupiter | +1  | 95%   | 0  | 7                      | 86%   |
|         |   |   |  | 8                      | (88% using ideal<br>dates)                        |



|        |    |     |    |    |                         |
|--------|----|-----|----|----|-------------------------|
| Saturn | -6 | 98% | -7 | 13 | 31%                     |
|        |    |     |    | 15 | (27% using ideal dates) |

**Table 5.10: A summary of Greek-letter phenomena date corrections when comparing expected date corrections from Chapter 4’s theoretical analysis with date corrections from Babylonian records of Greek-letter phenomena.**

From Table 5.10, we see that the Babylonian astronomers did not generally apply a date correction to Mercury’s Greek-letter phenomena, despite the theoretical data suggesting that a date correction of -1 day would be most commonly seen. This might imply that quite often the Babylonian astronomers would be expecting to observe Mercury for the first time the day *after* its true first visibility, and watching out for it a day too late. However, given that Mercury is notoriously difficult to spot at the time of its appearance or disappearance (due to, for example, the challenges of spotting a small object on a bright horizon close to the Sun), I do not believe that this makes the Babylonian corrections “wrong” in any way. Instead I suspect it highlights the difference between the limits of observation under ideal observing conditions and what may be possible in real-life observing conditions. Further issues concerning Mercury’s visibility patterns are analysed in Chapter 7.

### 5.3 Conclusions

In conclusion, there is generally a high level of agreement between the planetary records found in a Goal-Year Text, and the Almanacs or Normal Star Almanacs predicting events for the goal year. This suggests that the records found in the Goal-Year Texts could have been used in the creation of the Almanacs and Normal Star Almanacs. Statistical analysis of the records shows that, if this were the case, the Babylonian astronomers consistently applied small corrections of a few days to the dates of events from Goal-Year records, and that records of planet-Normal Star distances at the time of a planetary passage remain unchanged between the various texts. These date corrections generally agree very well with the theoretical date corrections which were calculated in the previous chapter.

Analysis of the Greek-letter phenomena dates also showed that, where both an observed date and an ideal date of an event were available, the predictions were much more likely to have been made using the ideal date. This is consistent with the view, discussed in Chapter 2, of an ideal date being an estimated correction to the date of an event, to take into account bad weather or other problems with observing. In other words, the “date correction” between an ideal and observed date could be viewed as a *modification* of the date correction applied across a planetary period (which is largely constant for each planet); a modification that varies from event to event depending on observing conditions. It therefore makes sense to use the ideal date, where one is necessary and available, as a starting point for predicting the dates of future events.

## Chapter 6

# The Babylonian calendar and its effect on goal-year methods of prediction

### 6.1 Introduction

The previous chapter investigated the accuracy of the Goal-Year periods and showed that small, regular corrections of a few days needed to be added or subtracted from these periods in order to predict the dates of planetary events accurately. We now need to investigate the effect of intercalation within the Babylonian calendar on Goal-Year methods of predicting phenomena.

Recall that the Babylonian calendar is a luni-solar calendar, where the lunar months were kept in line with the seasons by adding an additional thirteenth month in certain years.<sup>200</sup> During the Seleucid Era, the 19-year intercalation scheme now known as the Metonic cycle was used to determine which years would contain an intercalary month. Intercalary months would invariably be added in the following pattern: an additional month VI<sub>2</sub> (following Month VI) in year 1, and additional month XII<sub>2</sub> (following Month XII) in years 3, 6, 9, 11, 14 and 17.

For convenience, year 1 of the Metonic cycle is taken to be the year containing the additional Month VI<sub>2</sub>; this is essentially arbitrary.<sup>201</sup> This year 1 corresponds to years 18, 37, 56, etc, of the Seleucid Era, and every 19<sup>th</sup> year thereafter. The Metonic cycle was used without alteration for the entire Seleucid Era, and there is no evidence of deviation from this pattern of intercalary months in any of the extant Goal-Year Texts, Normal Star Almanacs or Almanacs.

#### 6.1.1 Goal-Year periods

As Chapter 4 showed, Goal-Year type planetary periods in the procedure texts are always expressed textually as a whole number of Babylonian years (occasionally with a date or longitude correction). However, as we know, the Babylonian year may contain either 12 or 13 months and is therefore not a constant unit of time. This implies that a Goal-Year period is not a constant length when expressed in years: it may sometimes end up being a month shorter or longer than the true period over which the planet's events recur.

It is more helpful to think of the Goal-Year periods in terms of lunar months. Table 6.1 summarises the planetary periods from the Goal-Year Texts, which were used by the Babylonian astronomers for the recurrence of planetary events. The table also shows the planets' theoretical periods expressed in terms of lunar months.

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<sup>200</sup> See Chapter 1's section on "Calendrical Systems".

<sup>201</sup> Neugebauer (1955), p. 33.

| Planet (period in Babylonian years) | Event type | Calculated period in lunar (Babylonian) months | Goal-Year period in lunar (Babylonian) months |
|-------------------------------------|------------|--|---|
| Mercury (46)                        | both       | 569 months - 1 day                             | 568 or 569                                    |
| Venus (8)                           | phenomena  | 99 months - 3 days                             | 98 or 99                                      |
| Venus (8)                           | passages   | 99 months - 1 day                              | 98 or 99                                      |
| Mars (79)                           | phenomena  | 977 months + 6 days                            | 977 or 978                                    |
| Mars (47)                           | passages   | 581 months + 14 days                           | 581 or 582                                    |
| Jupiter (71)                        | phenomena  | 878 months + 1 day                             | 878 or 879                                    |
| Jupiter (83)                        | passages   | 1027 months - 7 days                           | 1026 or 1027                                  |
| Saturn (59)                         | phenomena  | 730 months - 6 days                            | 729 or 730                                    |
| Saturn (59)                         | passages   | 730 months - 15 days                           | 729 or 730                                    |

**Table 6.1: A reminder of the planetary periods used in the Goal-Year Texts, expressed as lunar months plus or minus a number of days. The date corrections are the theoretical modal corrections calculated in Chapter 4.**

As Table 5.1 in the previous chapter showed, the number of Babylonian years spanned by a Goal-Year period could contain two different numbers of lunar months; the exact planetary period always falls between these two numbers. For example, events involving Mercury recur after almost exactly 569 months. In cases where the 46-year Babylonian Goal-Year period spans 569 months, the event will take place during the same month in both the goal year and the observation year. However, 46 Babylonian years can sometimes span only 568 months and, when this is the case, the event will occur a month later in the goal year than it did in the observation year.

Conversely, Jupiter’s planetary phenomena recur after almost exactly 878 months. When the 71-year Goal-Year period is 878 months long, the event will again take place during the same month in the goal year and the observation year. However, 71 Babylonian years can also be 879 months long. When this is the case, the event will occur a month earlier in the goal year than it did in the observation year.

Here I have defined the term “month shift” to refer to the date of a predicted event being changed by exactly one month to correct for the varying length of the Goal-Year period. It is important to clarify that this does not take into account whether the month changes due to the few days’ correction to the Goal-Year period shown in Table 6.1. Sometimes adding or subtracting a few days to the date of an observation can result in the predicted event being expected in a different month, when the observation date was close to the beginning or end of a month, but this correction is entirely independent of the month shift. In cases where the month shift was necessary, two corrections would be independently applied to the date: the few days’ correction would be added or subtracted and the expected event date would be moved forward or backwards by one month. In this chapter, we are only interested in the effect of the month shift.

To know when exactly this month shift would be necessary, we need to know what the pattern of intercalary months is near the year for which we would like to make predictions. It is clear that what affects the length of a Goal-Year period in lunar months is how many intercalary months fall within it. In other words, whether a month shift is needed depends on where the goal year falls within the Metonic cycle.

### 6.1.2 How often is the month shift necessary?

In the 19 years of the Metonic cycle there are 235 lunar months. For each of these 235 months, for each Goal-Year period, we can count forward the number of lunar months after which the planet’s events recur (column three of Table 6.1). From this we can

determine how often the observed and predicted events are expected in equivalent months, and in how many cases a month shift would be necessary. Table 6.2 summarises this for each planet, showing that a month shift is necessary around 21% of the time. However, the frequency of month shifts varies greatly by planet: for Mercury and Venus, a month shift is hardly ever necessary (only 6% of the time), while for Jupiter's Normal Star passages a month shift is needed 44% of the time.

| Planet (period in<br>Babylonian years)     | Event type | Number of months where: |                    |
|--|------------|-------------------------|--------------------|
|  |            | No month shift needed   | Month shift needed |
| Jupiter (71)                               | phenomena  | 195                     | 40                 |
| Jupiter (83)                               | passages   | 132                     | 103                |
| Venus (8)                                  | both       | 221                     | 14                 |
| Mercury (46)                               | both       | 221                     | 14                 |
| Saturn (59)                                | both       | 169                     | 66                 |
| Mars (79)                                  | phenomena  | 208                     | 27                 |
| Mars (47)                                  | passages   | 156                     | 79                 |
| Totals                                     |            | 1302                    | 343                |
| Percentage of months needing a correction: |            | 20.85%                  |                    |

**Table 6.2: The number of months in the 19-year Metonic cycle which require a month shift when using the Goal-Year periods.**

### 6.1.3 What patterns are there to the month shifts?

Having established that a month shift is needed around 21% of the time, the next step is to see what patterns there are in the distribution of month shifts within the Metonic cycle. Table 6.3 shows for each year of the Metonic cycle, for each planet, how many months are “different” (i.e. a month shift is needed) between the observations year and the goal year. A more detailed version of this table showing each month separately is given in Appendix H.

To illustrate this: if the goal year is year 1 of the cycle, a month shift would be seen in Months VI<sub>2</sub> to XII of the goal year (but not in Months I to VI) when predicting Jupiter's or Mars' Greek-letter phenomena, or Mars' Normal Star passages. A month shift would be seen in Months I to VI<sub>2</sub> of the goal year (but not in Months VII to XII) for Jupiter's Normal Star passages, or for events involving Venus, Mercury, or Saturn.

| Year of<br>Metonic Cycle | Jupiter<br>phenomena |    | Jupiter<br>passages |    | Venus<br>all events |   | Mercury<br>all events |   | Saturn<br>all events |    | Mars<br>phenomena |    | Mars<br>passages |    |
|--------------------------|----------------------|----|---------------------|----|---------------------|---|-----------------------|---|----------------------|----|-------------------|----|------------------|----|
| 1**                      | last                 | 7  | first               | 7  | first               | 7 | first                 | 7 | first                | 7  | last              | 7  | last             | 7  |
| 2                        |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  |                  | 0  |
| 3*                       | last                 | 1  | all                 | 13 |                     | 0 |                       | 0 | last                 | 7  | last              | 1  | last             | 1  |
| 4                        | all                  | 12 |                     | 0  |                     | 0 |                       | 0 |                      | 0  | first             | 6  | all              | 12 |
| 5                        |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  |                  | 0  |
| 6*                       |                      | 0  | all                 | 13 |                     | 0 |                       | 0 | all                  | 13 |                   | 0  | last             | 1  |
| 7                        |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  | all              | 12 |
| 8                        |                      | 0  | last                | 6  |                     | 0 |                       | 0 |                      | 0  |                   | 0  |                  | 0  |
| 9*                       |                      | 0  | all                 | 13 | last                | 7 | last                  | 7 | all                  | 13 |                   | 0  | last             | 1  |
| 10                       |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  | first            | 6  |
| 11*                      | last                 | 1  | all                 | 13 |                     | 0 |                       | 0 |                      | 0  | last              | 1  | last             | 1  |
| 12                       | all                  | 12 |                     | 0  |                     | 0 |                       | 0 |                      | 0  | all               | 12 | all              | 12 |
| 13                       |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  |                  | 0  |
| 14*                      | last                 | 1  | all                 | 13 |                     | 0 |                       | 0 | all                  | 13 |                   | 0  | last             | 1  |
| 15                       | first                | 6  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  | all              | 12 |
| 16                       |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  |                  | 0  |
| 17*                      |                      | 0  | all                 | 13 |                     | 0 |                       | 0 | all                  | 13 |                   | 0  | last             | 1  |
| 18                       |                      | 0  |                     | 0  |                     | 0 |                       | 0 |                      | 0  |                   | 0  | all              | 12 |
| 19                       |                      | 0  | all                 | 12 |                     | 0 |                       | 0 |                      | 0  |                   | 0  |                  | 0  |

**Table 6.3:** Number of months where predictions made using the Goal-Year periods will occur in a *different* month from the observation year

We can see from Table 6.3 that, for any particular year, there are four types of month distribution:

- i) All (12 or 13 months) the same. This is the simplest, and most common, case – each month of the observation year predicts events for the same month of the goal year; no month shifts are necessary. If the goal year is year 2, 5, 13 or 16 of the Metonic cycle, no month shifts are necessary for any of the planets.
- ii) Half the year (6 or 7 months) the same, and half the year different. This occurs when either the observation year or the goal year contains a Month  $VI_2$ . Since none of the Goal-Year periods is of the right length that both the observations year and the goal year can contain a Month  $VI_2$  at the same time, obviously a month shift will always be necessary for half of the year in this case due to the extra month being added into the middle of one of the years.
- iii) 12 months the same and one different. This can happen when, for example, the observation year only has 12 months but the goal year has 13. If Month I of the observation year predicts Month I of the goal year, and so on up until Month XII predicts Month XII, then to predict Month  $XII_2$  of the goal year requires the month after Month XII of the observation year, which is of course Month I of the following year.
- iv) All (12 or 13 months) different. This type of distribution quite often follows on from type iii) – if Month I of an observation year has been used to predict the last month of a goal year, then Month II of the observation year will predict Month I of the next goal year, and so on, with all the dates being shifted backwards by one month. The month shift can also happen the other way round: sometimes Month I of the observation year predicts Month II of the goal year, and all the months needing to be shifted forwards instead. In this case, to predict Month I of the goal year we will need Month XII or  $XII_2$  from the end of the year *before* the observation year.

Putting all of this together will allow an “instruction manual” to be built up of when month shifts are necessary for any or all of the planets during any particular goal year. While it is impossible to prove exactly what methods the Babylonian astronomers used, this can be used to show whether the dates of Babylonian predictions demonstrate the month shifts at the expected points.

## ***6.2 Evidence from Babylonian sources***

### **6.2.1 A comparison of the dates of observations and predictions of planetary data**

It is now necessary to go to the Babylonian source material to investigate how the Babylonian astronomers took account of the month shifts in their predictions. A useful method of doing this is to look at the records in the same way as they would have been used by the astronomers: looking for examples of month shifts between the records in an Almanac or Normal Star Almanac and those in the Astronomical Diaries from one Goal-Year period back.

For an example of how to put this into practice, let us take the Normal Star Almanac for the year SE 189. Looking at the Astronomical Diaries for one Goal-Year period earlier for each planet, we find that only three useful Diaries are extant: those covering the years SE 118, for Jupiter’s Greek-letter phenomena; SE 181, for Venus’s Greek-letter phenomena and Normal Star passages; and SE 143, for Mercury’s Greek-letter phenomena and Normal Star passages.

SE 189 has an intercalary month  $VI_2$  making it year 1 of our reference Metonic cycle.

From Appendix H, we see that for Mercury and Venus we expect to find the following month shifts:

| Observation month                   | predicts | Goal-Year month              |
|-------------------------------------|----------|------------------------------|
| XII <sub>2</sub> (of previous year) |          | I                            |
| I                                   |          | II                           |
| II                                  |          | III                          |
| III                                 |          | IV                           |
| IV                                  |          | V                            |
| V                                   |          | VI                           |
| VI                                  |          | VI <sub>2</sub>              |
| VII-XII                             |          | VII-XII (no shift necessary) |

Comparing the records in the texts, we find the following:

27 GU<sub>4</sub>-UD *ina* ŠÚ<sup>sic</sup> *ina* ABSIN IGI ... *in* 25 IGI  
 “The 27th, Mercury's first appearance in the <east> in Virgo ... (ideal)  
 first appearance on the 25<sup>th</sup>.”  
 (ADART Vol II No. -168A, Obv. 12, Month **V**.)

25 GU<sub>4</sub>-UD *ina* NIM *ina* ABSIN IGI  
 “The 25th, Mercury's first appearance in the east in Virgo.”  
 (LBAT \*\*1055, Obv. 37-38 (Normal Star Almanac for SE 189), Month **VI**.)

Here we see the expected month shift.

GE<sub>6</sub> 11 *ina* ZALÁG G[U<sub>4</sub>-UD SIG] DELE šá IGI ABSIN 1 KÙŠ 8 SI  
 ...  
 [23 GU<sub>4</sub>-UD] *ina* NIM *ina* (SAG) RÍN ŠÚ  
 “Night of the 11<sup>th</sup>, last part of the night, Mer[cury was] 1 cubit 8 fingers  
 [below] γ Virginis. ...  
 [The 23<sup>rd</sup>, Mercury's] last appearance in the east in (the beginning of)  
 Libra.”  
 (ADART Vol II No. -168A, Obv. 19-25, Month **VI**.)

GE<sub>6</sub> 10 *ina* ZALÁG GU<sub>4</sub>-UD SIG DELE šá IGI ABSIN 1 KÙŠ 8 SI ...  
 23 GU<sub>4</sub>-UD *ina* NIM *ina* RÍN ŠÚ  
 “Night of the 10<sup>th</sup>, last part of the night, Mercury 1 cubit 8 fingers below  
 γ Virginis. ...  
 The 23<sup>rd</sup>, Mercury's last appearance in the east in Libra.”  
 (LBAT \*\*1055, Rev. 39-40 (Normal Star Almanac for SE 189), Month **VI**<sub>2</sub>.)

Here we see the expected month shift.

*in* 15<sup>?</sup> GU<sub>4</sub>-UD *ina* ŠÚ *ina* PA IGI  
 “Around the 15<sup>th</sup>? Mercury's first appearance in the west in Sagittarius.”  
 (ADART Vol. II No. -168A, Rev. 10<sup>?</sup>-11<sup>?</sup>, Month **VIII**.)

14 GU<sub>4</sub>-UD *ina* ŠÚ *ina* PA IGI

“The 14th, Mercury’s first appearance in the west in Sagittarius.”

(LBAT \*\*1055, Rev 48, (Normal Star Almanac for SE 189), Month **VIII**.)

Here no month shift was necessary.

*in* 2 GU<sub>4</sub>-UD *ina* ŠÚ [*ina* MÁŠ ŠÚ]

“Around the 2nd, Mercury’s [last appearance] in the west [in Capricorn].”

(*ADART* Vol. II No. -168E, Obv. 2-3, Month **IX**.)

2 GU<sub>4</sub>-UD *ina* ŠÚ *ina* MÁŠ ŠÚ

“The 2nd, Mercury’s last appearance in the west in Capricorn.”

(LBAT \*\*1055, Rev 51, (Normal Star Almanac for SE 189), Month **IX**.)

Here no month shift was necessary.

[...] USAN *dele-bat* SIG MÚL-MÚL 1 ½ KÙŠ

“[Night of the 15th] first part of the night, Venus was 1 1/2 cubits below η Tauri.”

(*ADART* Vol. III No. -130D, Rev. 12, Month **XII**.)

GE<sub>6</sub> 13 USAN *dele-bat* SIG MÚL-MÚL 1 ½ KÙŠ

“Night of the 13<sup>th</sup>, first part of the night, Venus 1 1/2 cubits below η Tauri.”

(LBAT \*\*1055, Rev. 68, (Normal Star Almanac for SE 189), Month **XII**.)

Here no month shift was necessary.

While, for Jupiter, we expect to find the following month shifts:

| Observation month | predicts | Goal-Year month           |
|-------------------|----------|---------------------------|
| I-VI              |          | I-VI (no shift necessary) |
| VII               |          | VI <sub>2</sub>           |
| VIII              |          | VII                       |
| IX                |          | VIII                      |
| X                 |          | IX                        |
| XI                |          | X                         |
| XII               |          | XI                        |
| XII <sub>2</sub>  |          | XII                       |

And, comparing the texts again, we find the following:

25 MÚL-BABBAR *ina* MAŠ-MAŠ ŠÚ

“The 25th, Jupiter’s last appearance in Gemini.”

(*ADART* Vol. II No. -193A, Rev. 3’, Month **II**.)



25 MÚL-BABBAR *ina* MAŠ-MAŠ ŠÚ  
 “The 25th, Jupiter's last appearance in Gemini.”  
 (LBAT \*\*1055, Obv. 12, (Normal Star Almanac for SE 189), Month **II**.)

Here no month shift was necessary.

*in* EN 26 MÚL-BABBAR *ana* ŠÚ *ki* UŠ-[a ...]  
 “Around the 26th, when Jupiter became stationary to the west [error for east ...]”  
 (ADART Vol. II No. -193B, Obv. 10', Month **VII**.)

26 MÚL-BABBAR *ina* TIL MAŠ- MAŠ UŠ  
 “The 26th, Jupiter stationary in the end of Gemini.”  
 (LBAT \*\*1055, Rev. 44, (Normal Star Almanac for SE 189), Month **VI**<sub>2</sub>.)

Here we see the expected month shift.

[*in*? E]N 24 MÚL-BABBAR *ana* ŠÚ *ki* UŠ-a ...]  
 “[Around?] the 24<sup>th</sup>, [when] Jupiter [became stationary] to the west [...]”  
 (ADART Vol II No. -193D, Rev. 15', Month **XI**.)

24 MÚL-BABBAR *ina* MAŠ-MAŠ UŠ  
 “The 24th, Jupiter stationary in Gemini.”  
 (LBAT \*\*1055, Rev. 58, (Normal Star Almanac for SE 189), Month **X**.)

Here we see the expected month shift.

In every case, the predicted events follow the expected pattern: month shifts are found at the points where we would expect them to have been necessary, and are not found at the points where we would expect them to have been unnecessary.

We can also compare months of predicted events with observational data from Goal-Year texts, given that (as shown in §2.7) these texts appear to have been compiled directly from Diary observations. From this we can ascertain whether the month shift was added in at the point when the Diary records were copied into the Goal-Year texts, or, as with the date corrections, at the point when the records were copied from the Goal-Year texts into the Almanacs or Normal Star Almanacs.

Below are some examples of record comparisons between the Diaries, Goal-Year Texts and the predictive texts.

[... EN 23 AN *ana* ŠÚ *ki* UŠ-a nn mm *ár* MÚL TUR šá 4 KÙŠ] ‘*ár*  
 LUGAL ...  
 “[Around the 23rd, when Mars became stationary to the west, it became stationary ... behind q Le]onis ...”  
 (ADART Vol. II No. -261B, Rev. 5', Month **XII**.)

EN 23 AN *ana* ŠÚ *ki*-‘*i*’ [...] ...]  
 “Until the 23rd, when Mars [became stationary] to the west...”

(*ADART* Vol. VI No. 27, Obv. 33, (Goal-Year Text for SE 129, observational data from year SE 50), Month **XII**.)

[...] AN *ina* A UŠ

“[23-28th...], Mars stationary in Leo”

(LBAT \*\*1123, Rev. 3, (Almanac for SE 129), Month [**XII**].)

Here no month shift was necessary.

18 GENNA *ana* M[E E-*a*]

“The 18th, Saturn's acronychal rising.”

(*ADART* Vol. II No. -263, Obv. 14'. Month **IX**.)

*in* 18 GENNA *ana* ME E-*a*

“Around the 18th, Saturn's acronychal rising.”

(*ADART* Vol. VI No. 18, Obv. 5' (Goal-Year Text for SE 107, observational data from year SE 48), Month **IX**.)

13 GENNA *ana* ME E-*a*

“The 13th, Saturn's acronychal rising.”

(LBAT 1016, Rev. 3', (Normal Star Almanac for SE 107), Month **X**.)

Here there is no month shift between the Diary observation and the Goal-Year Text record, but we see the expected month shift when comparing the Goal-Year Text and the Normal Star Almanac.

This shows that the month shift was added in when necessary *after* the Goal-Year text was created – i.e. in using the Goal-Year Text to produce the Almanac or Normal Star Almanac. This is consistent with the findings of Chapter 5, which showed that the date correction would have been added when using the Goal-Year Text to produce the Almanac or Normal Star Almanac, rather than when the Diary records were copied into the Goal-Year text.

However, this is inconsistent with the practice concerning lunar records. It has been shown that, where a month shift was necessary for the 18-year lunar period, Lunar Six values were occasionally recorded in the Goal-Year Text under the predictive month rather than the month in which they were observed.<sup>202</sup> This relabelling has only been found in Goal-Year Texts for years prior to SE 118. In other words, for Lunar Six events before this date, the month shift was applied when copying the Diary records into the Goal-Year Text. There is no evidence of this practice ever occurring in the planetary sections of Goal-Year Texts.

This means that, for planetary events, the month of an event recorded in the Goal-Year texts is always the month in which the event was observed, rather than the month of the event to be predicted (when these months differed). When looking for month shifts, we can therefore treat records from Goal-Year texts as being in the same dataset as records from Diaries.

The observational records from the Diaries and Goal-Year texts were compared with those from the Almanac or Normal Star Almanac one Goal-Year period later, to find

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<sup>202</sup> Brack-Bernsen (1999b), Gray & Steele (2009).

evidence of month shifts. Table 6.4 summarises the results of these comparisons, showing, for each planet, how many of the record comparisons demonstrated a month shift and how many did not. Full details of the records used for this comparison can be found in Appendix I.

|              | Number of records showing:   |                           |                             | Total |
|--------------|------------------------------|---------------------------|-----------------------------|-------|
|              | No month shift<br>(expected) | Month shift<br>(expected) | Month shift<br>(unexpected) |       |
| Jupiter (71) | 25                           | 3                         | 1                           | 29    |
| Jupiter (83) | 1                            | 1                         | 0                           | 2     |
| Venus (8)    | 65                           | 1                         | 0                           | 66    |
| Mercury (46) | 92                           | 7                         | 0                           | 99    |
| Saturn (59)  | 18                           | 6                         | 0                           | 24    |
| Mars (79)    | 17                           | 1                         | 0                           | 18    |
| Mars (47)    | 24                           | 6                         | 0                           | 30    |
| Total        | 242                          | 25                        | 1                           | 268   |

**Table 6.4: A summary comparing planetary data from Astronomical Diaries and Goal-Year Texts with Almanacs and Normal Star Almanacs, to look for evidence of month shifts in the record dates.**

The table shows that the Babylonian records fit in with our theoretical pattern of month shifts extremely well. For all the predictions of events during months where we have shown that a month shift would be necessary, the expected month difference is found between the observational record and the predictive record of the event. Likewise, in all but one of the cases where we have shown that a month shift would *not* be necessary, no month difference is found between the observational and the predictive record. There is only one anomaly to address: for one prediction of a Jupiter phenomenon, the records seem to show a month shift in a place where we would not expect it. This involves the Diary for year SE 174, and the Almanac for SE 245.

[...] MÚL-BABBAR *ina zib<sup>me</sup>* ŠÚ  
 “[...] Jupiter’s last appearance in Pisces.”  
 (ADART Vol III No. -137E, Rev. 5’. Month **XII**.)

25 MÚL-BABBAR *ina zib<sup>me</sup>* ŠÚ  
 “The 25<sup>th</sup>, Jupiter’s last appearance in Pisces.”  
 (LBAT \*1179-80, rev. 22, (Almanac for SE 245), Month **XI**.)

At first glance, this seems like an unnecessary month shift. However, calculations show that Jupiter’s last visibility should have taken place around day 29 of Month XI in SE 174, and around day 28 of Month XI in SE 245; no month shift was necessary in this case.<sup>203</sup> Therefore it is the *observation* which shows the “wrong” date; were this just a case of an incorrectly applied month shift, we would expect to see a correct observation date leading to an incorrect prediction date.

For the Diary record, the day of the event is broken away and the record comes from an end of the month summary, preventing us from deducing when in the month it was observed. The most simple explanation therefore seems to be that the phenomenon could have been observed in SE 174 at the very beginning of Month XII, only a day or two away

<sup>203</sup> These dates are taken from Roughton’s theoretical tables of event dates – see §1.4.3 as before.

from the calculated approximate date of Month XI day 29. It may then seem odd that the predicted date of the event in SE 245 would then be several days earlier than the observed date in SE 174, given that the dates of Jupiter's phenomena do not usually need to be corrected between one Goal-Year period and the next (see Table 6.1). Perhaps it was cloudy around the time of Jupiter's disappearance, and the Babylonian astronomers decided that the planet's last visibility would actually have been a few days earlier than they recorded? We cannot be certain. Nevertheless, it seems most probable that this discrepancy should not be considered an erroneous month shift.

Again, we cannot conclude from this anything about the methods the Babylonian astronomers may have used kept track of when a month shift was or was not necessary. All we can conclude from the data is that they were aware of the need for month shifts when making predictions, and when to apply them.

## 6.2.2 Reports of intercalary months in the planetary sections of the Goal-Year Texts

Some evidence for ways in which the Babylonian astronomers kept track of the calendrical system may be found in the Goal-Year Texts. In the planetary observations sections we find the occasional note that the observation year, or the year previous to it, was intercalary. This note is not connected to a specific observation, but instead appears to be purely calendrical in character. For example, consider the goal year SE 106:

Jupiter's Greek-letter phenomena, observation year = SE 35:

MU-34-KAM ŠE DIR MU-35-KAM <sup>1</sup>An-ti-<sup>u</sup>-uk-su u <sup>1</sup>S]e-lu-ku  
LUGAL<sup>meš</sup>  
“Year 34: month XII was intercalary. Year 35, kings Ant[iochus and]  
Seleucus.”  
(followed by records for SE 35 as normal)  
(ADART Vol VI No. 15, Obv. 1 (Goal-Year Text for SE 106))

Jupiter's Normal Star passages, observations year = SE 23:

MU-23-KAM <sup>1</sup>Se-lu-ku u <sup>1</sup>An-ti-<sup>u</sup>-[uk-su LUGAL<sup>m</sup>]<sup>es</sup>  
“Year 23, [kings] Seleucus and Antiochus.”  
(records for SE 23 as normal, followed by)  
ŠE DIR  
“Month XII was intercalary.”  
(ADART Vol VI No. 15, Obv. 4 and 7 (Goal-Year Text for SE 106))

Also of interest are the Goal-Year Texts where planetary observations are included for not only the observation year, but also sometimes the end of the preceding year or the beginning of the following year. For example, consider the goal year SE 118:

Jupiter's Normal Star passages, observations year = SE 35:

MU-34-KAM <sup>1</sup>An-ti-<sup>u</sup>-uk-su u <sup>1</sup>Se-lu-ku LUGAL<sup>meš</sup> DIR-ŠE GE<sub>6</sub> 22  
USAN MÚL-BABBAR e šur GIGIR šá ULÙ ½ KÙŠ  
“Year 34, kings Antiochus and Seleucus. Month XII<sub>2</sub>, night of the 22<sup>nd</sup>,  
first part of the night, Jupiter was ½ cubit above ζ Tauri.”

(records for SE 35 as normal, followed by)

MU-36-KAM BAR GE<sub>6</sub> 1<sup>2</sup> 'USAN MÚL-BABBAR *ana* NIM *ina*<sup>1</sup>  
[LAL-šú] SIG MAŠ- MAŠ *ár* 2 KÙŠ  
“Year 36. Month I, night of the 1<sup>st</sup>, first part of the night, Jupiter,  
while moving back to the east, was 2 cubits below β Geminorum.”  
(*ADART* Vol VI No. 20, Obv. 5 and 8 (Goal-Year Text for SE 118))

In total 20 Goal-Year Texts include a remark that an observation year was intercalary (that is, specifically using the phrasing “Month XII was intercalary” rather than any references to events within the intercalary month), and 16 record that the year before the observation year was intercalary. 10 include records for the month XII or XII<sub>2</sub> of the year before the observation year, and 13 include records for Month I of the year following the observation year. Full details of which texts included these records are available in Appendix J.

The frequency of these “Month XII was intercalary” remarks is much too low for them to have been included as a matter of course for every intercalary month, even taking into account that some of the now-damaged texts may once have contained more such entries. Instead, we can test whether the remarks may have been connected with the issue of month shifts. There are four types of remarks to explain:

- i) Records of events occurring within Month XII or XII<sub>2</sub> of the year before the observation year. These all occur at points where either a month shift was necessary, or a correction to the date meant that these records from the previous year were needed to predict Month I of the goal year.
- ii) Records from Month I of the year following the observation year. All of these cases involve records in the first few days of Month I, where the necessary correction subtracted a few days (again, refer to Table 6.1 for these corrections) and hence would put the records within the goal year. None of these records are due to a month shift.
- iii) A remark that the observation year had an intercalary month. It seems believable that these remarks are to keep track of the calendar by ensuring that the intercalary months are noted whether or not there are any planetary events recorded for the month. The presence of a “Month XII was intercalary” remark does not seem to have any connection to whether or not there were any planetary events recorded for the Month XII<sub>2</sub> of that year.
- iv) A remark that the year before the observation year had an intercalary month. At first glance it seems that these entries would have been an excellent way to keep track of when a month shift was necessary, particularly for Jupiter and Saturn which move slowly enough that they regularly would have no events of interest occurring within the Month XII or XII<sub>2</sub>. However, this explanation is not borne out by the texts. Some of the remarks occur when a month shift would be necessary, but many do not. Similarly, there are many cases where a month shift is necessary and entries of this kind do not occur, even when the previous year was intercalary.

As the Appendix shows, the remarks concerning intercalary months span the entire range of extant Goal-Year Texts, from goal year SE 79 to SE 247. Therefore, this is not evidence of a change in practice over time (as was the case with the relabelling of Lunar Six data) so much as, perhaps, evidence of an inconsistent practice. The Goal-Year Texts were compiled across two centuries, possibly more; we do not know how many people were involved in their creation during that time. The fact that these remarks do not seem to

occur in any particular pattern may just be an artefact of different astronomers' varying preferences concerning how to keep track of intercalary months in the texts. Unfortunately, none of the extant Goal-Year Texts include any information concerning their authors and so this possibility cannot be investigated further.

### ***6.3 Conclusions***

I have shown that when using Goal-Year methods to make predictions of planetary or lunar events, the month of the predicted event occasionally needs to be changed due to the calendar system in use. From the analyses presented in this chapter, several conclusions can be drawn about how this problem may have been approached by the Babylonian astronomers.

Firstly, by comparing observational data in the Astronomical Diaries with predictive data in the Almanacs and Normal Star Almanacs, we have seen that the texts contain evidence of the month shifts. These month shifts occur within the records we would theoretically expect to find it, and only in those records. This shows that the Babylonian astronomers were aware of the necessity of month shifts, and knew when to apply them. It does not show in any way how they kept track of which months needed month shifts.

Secondly, comparing observational records in Astronomical Diaries and Goal-Year Texts has shown that, for the planetary data, this month shift was always applied when the Goal-Year Text data was written into Normal Star Almanacs and Almanacs, rather than when the Diary records were written into Goal-Year Texts.

Lastly, by investigating calendrical remarks in the Goal-Year Texts we have seen that these remarks serve several purposes: some are connected with date corrections and month shifts, but not all of them, and the purpose of a lot of the remarks is still unclear. This inconsistent practice could be simply explained by the many scribes who compiled these texts over the centuries employing different practices of record-keeping.

## Chapter 7

### Mercury's “omitted” visibility phases

As mentioned in Chapter 1, the Goal-Year type texts occasionally make note of an appearance or disappearance of Mercury where the planet was not observed, and in fact was not observable from Babylon, for the entire eastern or western phase. In these records the terminology “UD-DA (IGI/ŠÚ) DIB” is found, in place of the zodiacal sign which would normally be expected in a visibility record. Sachs & Hunger translate this phrase as “first/last appearance ..., omitted”.<sup>204</sup> DIB, literally translated as “it will pass by”, is found alongside similar remarks in records of eclipses which were not observable from Babylon.<sup>205</sup>

However, very few of the researchers into Babylonian planetary theories have written in any detail about *why* the omitted phases occur. For this reason I shall start with a description of the factors which affect Mercury's motion and visibility from Earth, and how these interact, to aid an understanding of why and when the omitted phases happen.

#### 7.1 What factors affect Mercury's visibility?

A planet's visibility is affected by the interaction of several variables, including the planet's elongation from the Sun, its latitude, the angle of the ecliptic to the horizon (which depends on the time of year and the observer's location on Earth), and other factors which cannot be reproduced so easily such as the observing conditions at the horizon on any particular day. Note that one factor which has not been fully analysed in this chapter is Mercury's highly variable apparent magnitude, which can vary between approximately -2 and +5.5 when viewed from Earth. Clearly this will have an important impact on whether or not Mercury can be observed, an impact which will be fully investigated in future work. However, Mercury's variable magnitude is not considered further in this chapter.

The Earth's daily motion means that, relatively, the ecliptic appears to move around it at a constant rate. For a planet which travels with the ecliptic (such as Mercury) to be observable from Earth, it needs to be far enough away from the Sun that it will still be in the sky when the Sun is sufficiently far below the horizon that the sky is dark. In other words, for a morning appearance it needs to rise far enough *before* the Sun, and for an evening appearance it needs to set far enough *after* the Sun.<sup>206</sup> Exactly how far away it needs to be depends on the ecliptic's angle with the horizon: if the ecliptic is relatively perpendicular to the horizon, then arcs of the ecliptic will be seen to rise and set faster: the planet will need a larger elongation (longitude difference) from the Sun to be above the horizon when the Sun is far enough below the horizon.

Conversely, if the ecliptic-horizon angle is comparatively low, then the ecliptic arcs will rise and set relatively slowly – even though the ecliptic is moving at the same speed, less of the motion will be in a direction perpendicular to the horizon. Therefore, for a planet at the same elongation as before, there will be a longer period where the planet is above the horizon but the Sun is far enough below it. The planet can also be spotted when it is at a smaller elongation from the Sun.

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<sup>204</sup> Sachs & Hunger (1988), p. 25.

<sup>205</sup> Steele (2001-2).

<sup>206</sup> The vertical distance below the horizon which the Sun must have reached for the planet to be visible, taking into account these factors of elongation, latitude, etc., is referred to as the *arcus visionis*. See for example Neugebauer (1975), p. 234.

## Vernal Equinox

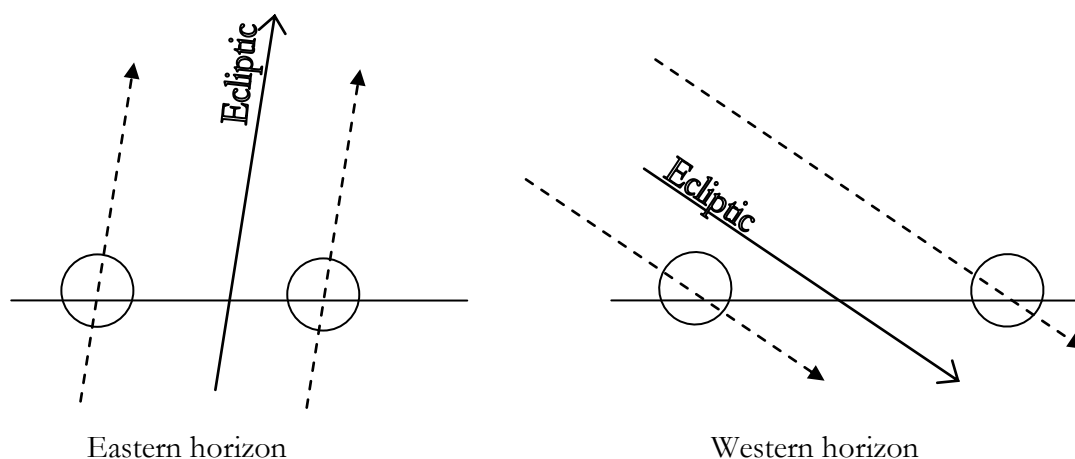


Figure 7.1a: a schematic illustration of Mercury rising with a positive or a negative latitude around the time of the vernal equinox. Note that the ecliptic-horizon angle is at its largest at this time, and so whether Mercury has a positive or negative latitude makes little difference to how long before sunrise it becomes visible.

Figure 7.1b: a schematic illustration of Mercury setting with a positive or a negative latitude around the time of the vernal equinox. In this case the ecliptic-horizon angle is at its shallowest, and so Mercury remains visible after sunset for significantly longer when its latitude is positive rather than negative.

## Autumnal Equinox

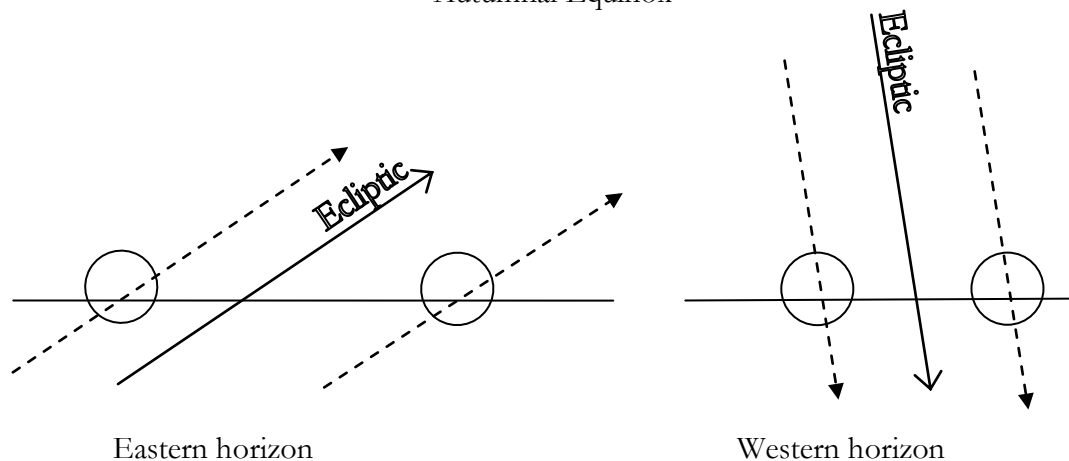


Figure 7.1c: a schematic illustration of Mercury rising with a positive or a negative latitude around the time of the autumnal equinox. In this case the ecliptic-horizon angle is again at its shallowest, and so Mercury becomes visible for significantly longer before sunrise when its latitude is positive rather than negative.

Figure 7.1d: a schematic illustration of Mercury setting with a positive or a negative latitude around the time of the autumnal equinox. The ecliptic-horizon angle is again at its largest at this time, and so whether Mercury has a positive or negative latitude makes little difference to how long after sunset it remains visible.



Since Babylon's latitude is approximately  $32.5^\circ$ , the angle between the celestial equator and the horizon is  $(90-32.5) = 57.5^\circ$ , and so the angle between the ecliptic and the horizon can vary between  $57.5^\circ \pm 23.5^\circ$  (because the Earth's axial tilt is  $23.5^\circ$ ). In other words, from Babylon the ecliptic-horizon angle can be a minimum of  $34^\circ$  and a maximum of  $81^\circ$ .

Around the vernal equinox (Month XII<sub>(2)</sub> or I of the Babylonian year), the ecliptic-horizon angle is at its maximum value at sunrise and at its minimum value at sunset, with the opposite being true around the autumnal equinox (Month VI<sub>(2)</sub> or VII). (Around the solstices, the ecliptic-horizon angle will of course be around its median value at both sunrise and sunset.) From the above paragraphs, this suggests that Mercury will be observable at a lower elongation (and so will be visible for a longer period) at sunset in Month I and at sunrise in Month VII, than would be necessary at sunrise in Month I and at sunset in Month VII.

However, this is not the full story because we also need to consider the effect of Mercury's latitude. This is illustrated in Figures 7.1a-d, which demonstrates that latitude is much more important when the ecliptic-horizon angle is low. From inspection of Figures 7.1b and c we see that, when the angle is low, a planet with a positive latitude will be above the horizon for a significantly longer length of time than one with a negative latitude. When the latitude is negative, the elongation will need to be much larger for the planet to be above the horizon far enough away from the Sun.

At the other extreme, Figures 7.1a and d show that when the ecliptic-horizon angle is high, a planet's latitude is almost irrelevant because objects at the same longitude rise at almost the same time whether they have a positive or negative latitude. At this point Mercury will rise roughly the same amount of time before the Sun irrespective of its latitude, and so the time difference between Mercury rising and the Sun getting close enough to the horizon for Mercury to disappear will be mostly dependent on Mercury's elongation from the Sun.

To summarise these criteria: Mercury can be seen for the longest when both the ecliptic-horizon angle is low (at sunset in Month I and sunrise in Month VII) *and* it has a high latitude. It can be seen at smaller elongations under these conditions than any others, so its periods of visibility will be longer. When the ecliptic-horizon angle is large (at sunrise in Month I and sunset in Month VII), Mercury will need to be at a larger elongation in order to be seen. However, it can be seen at a much lower latitude than in the previous case where a high latitude was important.

The omitted phases are invariably those which would occur shortly after the vernal equinox (for morning phases) and around the autumnal equinox (for evening phases) – i.e. when the ecliptic-horizon angle is large. Therefore, the omitted phases occur due to this combination of effects: when Mercury's latitude is extremely negative, the ecliptic-horizon angle is large, and Mercury's elongation from the Sun does not reach a large enough magnitude for it to be visible from Babylon. These effects combine to make a complex function for whether or not an appearance of Mercury will “pass by” Babylon. Perhaps this complexity is the reason that very little of the literature offers a reason as to *why* these omitted phases exist, simply taking it for granted that they do.<sup>207</sup>

Sachs & Hunger say that the omitted phases occur “because of unfavourable visibility conditions”,<sup>208</sup> a vague turn of phrase with the unfortunate implication, in my opinion, that

<sup>207</sup> The issues are of course very similar to those surrounding visibility of the Moon around conjunction, as discussed and illustrated in, for example, Brack-Bernsen (1999a).

<sup>208</sup> Sachs & Hunger (1988), p. 25.

*weather* may be preventing the observation. This is not the case, as demonstrated above. In the Astronomical Diaries there is a clear difference of terminology between observations which were prevented because of the weather, which are generally accompanied by a weather description and the remark NU PAP (“I did not watch”<sup>209</sup>), and missed Mercury observations which use the DIB terminology.

The theoretical schemes in *ACT* for calculating Mercury’s phenomena include its omitted phases (a fact which reinforces that they are not just an issue of observational technique or adverse weather conditions). As Neugebauer explains, the known Mercury schemes compute certain phenomena by adding on “pushes”, or given numbers of days and amounts of longitude, to the values for previously calculated phenomena.<sup>210</sup> Therefore the omitted phases need to be included for the calculations to work, even though they will not be observed. He shows that from the Babylonian astronomers’ point of view, whether a phase becomes omitted (in one of the variant schemes, at least), is strongly dependent on Mercury’s longitude at the point of first appearance, with morning phases between 10° and 50° longitude, and evening phases between 180° and 215° longitude being omitted.<sup>211</sup> This is consistent with the theory explained above, because Mercury’s longitude is strongly linked to the time of year, as is the ecliptic-horizon angle.

However, Neugebauer does not offer at this point any particular explanation of *why* the Mercury phases are not visible. He says, confusingly, that between these longitude points “the phenomena ... are so close to each other that they will not be visible at all”.<sup>212</sup> Since he does not expand on the remark at this point, one is left with the impression that the phases are omitted due to the calculated first and last visibilities occurring on the same day, perhaps. Again, this is not the case.

Neugebauer’s other writings on the subject of computing Mercury’s visibilities also discuss these omitted phases, but generally offer little explanation of why they occur. *The Babylonian Method for the Computation of the Last Visibilities of Mercury*<sup>213</sup> confirms the meaning of the terminology which denotes an unobservable phenomenon but, along with *Babylonian Planetary Theory*,<sup>214</sup> does not specifically discuss any of the issues relating to omitted phenomena. *The Exact Sciences in Antiquity* offers a partial explanation, including a figure of an inferior planet’s motion relative to the Sun and its phases of visibility and invisibility,<sup>215</sup> and stating that in some parts of the zodiac Mercury “remains so close to the sun that it should be dotted as invisible”.<sup>216</sup>

It is not until his *HAMA* that Neugebauer includes an explanation of the issues behind the occurrence of omitted phases, and the mechanics involved.<sup>217</sup> He shows that Ptolemy was aware of the ways in which the effects of Mercury’s latitude and elongation and the ecliptic-horizon angle combine to prevent the planet being visible at certain longitudes.<sup>218</sup>

More recent researchers into Babylonian planetary theory have written surprisingly little on this issue. Swerdlow’s major work on planetary theory states simply that “there are regions

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<sup>209</sup> The NU PAP terminology was examined in §2.1.1.

<sup>210</sup> See Neugebauer (1955), the section “Theory of Mercury”, pp 287-299.

<sup>211</sup> Neugebauer (1955), p. 288; see also pp 366-371, Procedure Text 801.

<sup>212</sup> Neugebauer (1955), p. 367.

<sup>213</sup> Neugebauer (1951).

<sup>214</sup> Neugebauer (1954).

<sup>215</sup> Neugebauer (1969), p. 127.

<sup>216</sup> Neugebauer (1969), p. 132.

<sup>217</sup> Neugebauer (1975), p. 404.

<sup>218</sup> Neugebauer (1975), pp. 239-242, discussing section XIII 8 of the *Almagest* (Toomer 1998, pp. 640-645).

in which an entire morning or evening phase is omitted because the planet does not reach sufficient elongation from the sun to be visible”<sup>219</sup> – true, but far from a complete explanation, as we have seen. Neither Hunger & Pingree’s<sup>220</sup> nor Brown’s<sup>221</sup> recent works on Babylonian astronomy make anything more than brief references to the omitted phenomena.

Mercury’s omitted phases represent an interesting problem in the context of the observational texts. Obviously it is impossible to determine their dates by observation alone; in other words, direct observation cannot distinguish “Mercury is in a period of invisibility” from “Mercury is in a period of visibility which cannot be observed”. Diary dates of omitted appearances and disappearances therefore must have been computed.

How might this have been done? In the later part of the period, the omitted dates could have been predicted very easily using the Goal-Year methods described in Chapter 5. As Chapter 4 showed, Mercury’s longitudes recur very closely after a 46-year period, and so if one phase is recorded as being omitted then the corresponding phase 46 years later is practically certain to be omitted too. However, the earliest extant observations of omitted Mercury phases date to the early part of the 4<sup>th</sup> century BC,<sup>222</sup> over 100 years before the earliest extant Normal Star Almanacs.

Some other method must have been used to estimate the earlier dates, and it is possible that inspection of Mercury’s Greek-letter phenomena records from the Diaries would have been enough to accomplish this, in a method analogous to the calculation of Lunar Sixes in the Diaries. Recall that compilations of Lunar Six values were available dating back to at least the 7<sup>th</sup> century BC,<sup>223</sup> and that methods existed allowing values which were not observed to be calculated and added into the Diaries;<sup>224</sup> it seems relatively likely that similar methods could have led to an interested observer working out the details of Mercury’s missing phases quite straightforwardly.

Mercury’s extremely fast motion means that in a typical Babylonian year it will appear and disappear five or six times, so a complete archive of many years’ observations<sup>225</sup> would very quickly contain enough records to gain an understanding of how long Mercury tended to remain visible or invisible in certain phases, and how much its longitude tended to change between one phenomenon and the next. This could easily lead to an awareness that Mercury never became first visible within particular ranges of longitude, and by combining these two pieces of knowledge an observer could regularly check whether Mercury’s next expected appearance would be omitted by adding a particular amount of longitude onto an observed last appearance – a crude version of the later *ACT* methods described above.

This does seem to be a plausible way of estimating the dates although it is, of course, speculation on the Babylonian astronomers’ methods with no direct evidence. Yet the techniques involved would be entirely in keeping with what we know about their methods in other areas such as the early development of lunar predictions.

The rest of this chapter studies the records in a similar manner as I speculate the

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<sup>219</sup> Swerdlow (1998), p. 106.

<sup>220</sup> Hunger & Pingree (1999).

<sup>221</sup> Brown (2000).

<sup>222</sup> The earliest examples are found in *ADART* Vol. V No. 59.

<sup>223</sup> Huber & Steele (2007).

<sup>224</sup> Brack-Bernsen & Hunger (2002).

<sup>225</sup> As was of course available to the Babylonian astronomers in the form of Astronomical Diaries and except texts. The earliest Mercury phenomena excerpts in *ADART* Vol. V are dated to -586 (No. 53).

Babylonian astronomers might have done with the data we know were available to them: by seeing what patterns can be found in the Mercury records. The following sections will examine the records of Mercury's Greek-letter phenomena in the Goal-Year type texts to see what patterns can be deduced in two specific areas: the longitude and latitude dependence of Mercury's appearances and disappearances, and the longitude dependence of the length of Mercury's periods of visibility and invisibility. These patterns can then be compared with the theoretical expectations and the methods from *ACT*.

## 7.2 Textual evidence of the factors affecting Mercury's visibility phases

### 7.2.1 Theoretical longitude and latitude dependences

Figure 7.2a-d show the sidereal longitudes and latitudes of Mercury on the theoretical date of each of its Greek-letter phenomena across the Late Babylonian Period.<sup>226</sup> Each figure contains around 1600 data points, covering a period between -600 and 75 AD. As previously stated, it is impossible to determine the exact date of a planet's appearance or disappearance due to observing conditions which cannot be reproduced. However, the criteria which Roughton has used for determining visibility produce a longitude-latitude dependence for Mercury which generally agree with the theory. The figures show that, as expected, Mercury's latitude at the point it first becomes visible depends strongly on its longitude (i.e. it depends on the time of the year and, by extension, the horizon-ecliptic angle, as we have seen). For example, Mercury's latitude at the point it becomes visible in the east shows a maximum value at a longitude of around  $240^\circ$  to  $270^\circ$ ; this corresponds to December and early January, i.e. around and after the winter solstice. For Mercury's western phases, the latitude at which it becomes visible shows a maximum value at a longitude of around  $70^\circ$  to  $100^\circ$ ; this corresponds to late May and June, i.e. before and around the summer solstice.

Figure 7.2a also shows that Roughton's visibility criteria omit all eastern first appearances between longitudes of around  $320^\circ$  to  $55^\circ$ . This corresponds to the period from mid-March to early June, i.e. around and after the vernal equinox when the ecliptic-horizon angle is at its highest (as we expected). From this we can conclude that Roughton's criteria for being able to view Mercury from Babylon broadly agree with *ACT* (recalling that *ACT* expected morning phases between  $10^\circ$  and  $50^\circ$  longitude to be omitted), but are somewhat stricter.

Figure 7.2c shows that Roughton's visibility criteria omit all western appearances between longitudes of around  $190^\circ$  to  $245^\circ$ . This corresponds to the period from mid-September to early November, i.e. around and after the autumnal equinox when the ecliptic-horizon angle is at its highest (again, as we expected). Recall that the scheme in *ACT* expected longitudes of between  $180^\circ$  to  $215^\circ$  to be omitted; again, Roughton's criteria broadly agree with the *ACT* scheme but set slightly different longitude limits.

Figures 7.2b and 7.2d show that the corresponding theoretical disappearances, between longitudes of  $350^\circ$  and  $75^\circ$  in the east and longitudes of around  $190^\circ$  and  $245^\circ$  in the west, are naturally also omitted.

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<sup>226</sup> Dates taken from Roughton's tables, as before (see Chapter 1). The tropical longitudes have been converted into sidereal longitudes using the correction formula from §3.5.

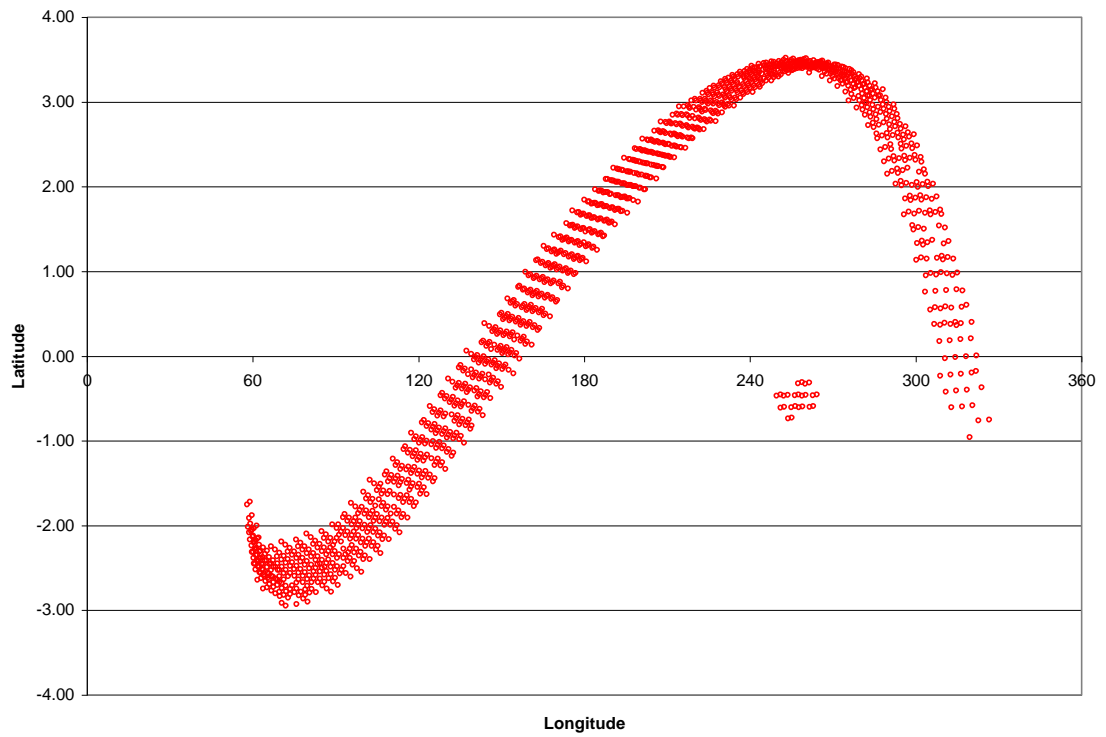


Figure 7.2a: theoretical longitudes/latitudes of Mercury's eastern appearances

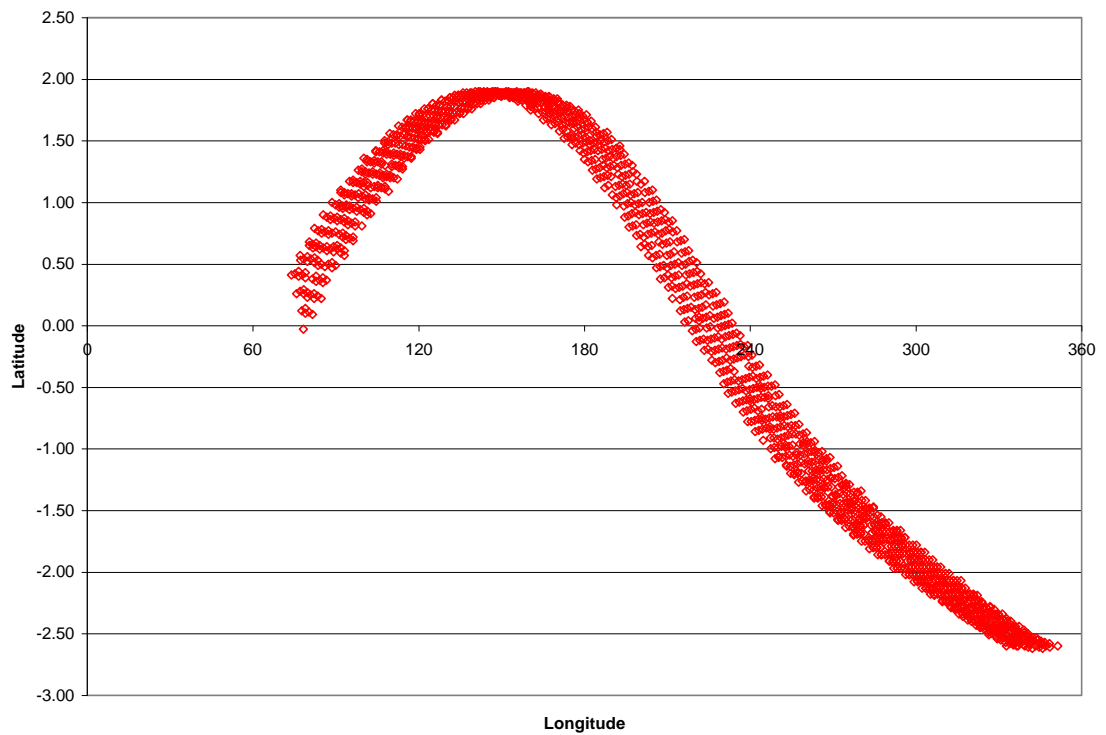


Figure 7.2b: theoretical longitudes/latitudes of Mercury's eastern disappearances

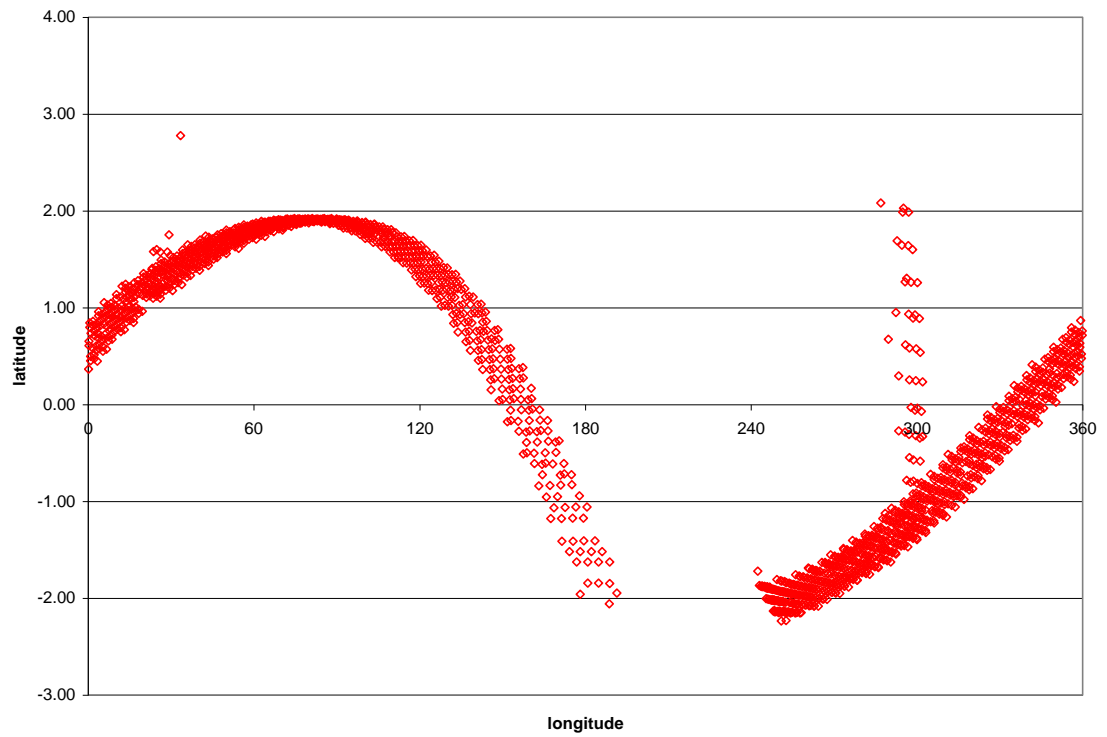


Figure 7.2c: theoretical longitudes/latitudes of Mercury's western appearances

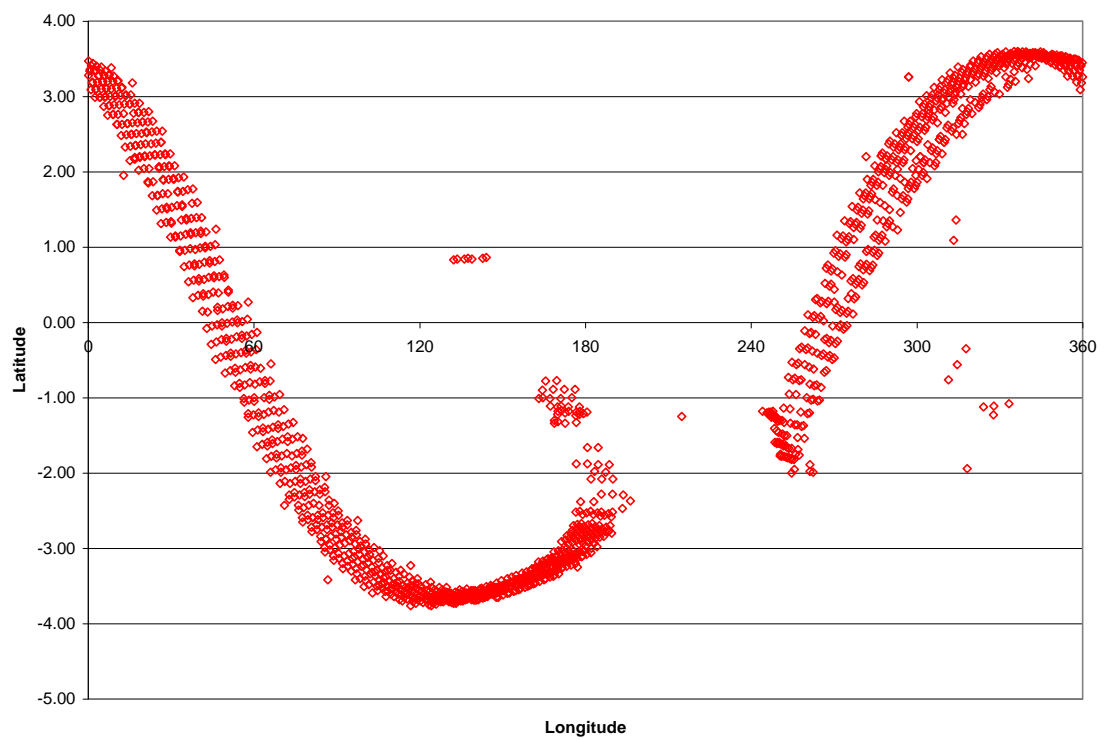


Figure 7.2d: theoretical longitude/latitudes of Mercury's western disappearances

### 7.2.2 Evidence from the non-mathematical astronomical texts

Having established the theoretical longitude and latitude dependences of Mercury's visibility, the next step is to investigate the observations and predictions in the non-mathematical astronomical texts. The following analysis uses a database (shown in Appendix K) of all records of Mercury's Greek-letter phenomena from *ADART* Vols. I-III, V, VI, and the Normal Star Almanacs and Almanacs listed in Tables 2.7 and 2.8. As before, for each record the Julian date was found<sup>227</sup> and Mercury's longitude and latitude on this date was calculated.<sup>228</sup> Because Mercury's longitude varies so fast, only records with a preserved date (or records where the date could be narrowed down to within a few days) were included.

In the following results, all of the records from the Astronomical Diaries, Goal-Year Texts and *ADART* Vol. V are analysed together as "observations", and all of the records from the Normal Star Almanacs and Almanacs are analysed together as "predictions". Previous chapters have shown that the Vol. V and Goal-Year Text records are excerpts from Diaries, so they all have the same ultimate source and need not be considered separately. Chapter 5 also showed that the records in the Normal Star Almanacs and the Almanacs need not be considered as separate sources of predictions either.

Figures 7.3a-d summarise the longitudes and latitudes of Mercury's observed and predicted Greek-letter phenomena. At this point one must draw attention to the small total number of available records (as usual) – caution must be exercised when trying to deduce gaps in the phenomena's longitude ranges, to check that they are not just a result of the relatively small amount of data. The number of records included in these figures are as follows:

Figure 7.3a (first eastern visibility):  
234 observations (of which 32 are recorded as omitted)  
45 predictions (of which 4 are omitted)

Figure 7.3b (last eastern visibility):  
202 observations (of which 21 are omitted)  
42 predictions (of which 5 are omitted)

Figure 7.3c (first western visibility):  
231 observations (of which 28 are omitted)  
45 predictions (of which 4 omitted)

Figure 7.3d (last western visibility):  
223 observations (of which 24 are omitted)  
41 predictions (of which 2 are omitted)

Comparing Figure 7.3a with 7.2a, and so on, shows that the longitude/latitude dependence of Mercury's appearances and disappearances in the Babylonian records closely match the theoretical values. As always, the figures contain occasional outlying points which do not fall on the expected curve. Some of these points would fit in with one of the other curves, by assuming that "first" or "east" was an error for "last" or "west", or vice versa. However, as discussed in previous chapters, one must be wary of ascribing too much to the explanation of "scribal error". Therefore, these outlying points have not been "corrected" in any way, beyond double-checking the text of the Babylonian record, the Julian date

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<sup>227</sup> Using Parker & Dubberstein (1956).

<sup>228</sup> Using the Bretagnon program, as before (see Chapter 1).

conversion, etc.

The longitude gap of each figure can be estimated in two ways: by showing the range of longitudes over which omitted records occur, and showing the range of longitudes over which non-omitted records are *not* found. Using both of these estimations will help reduce the problem of inaccuracies due to small datasets.

Figure 7.3a shows a maximum latitude of Mercury's first eastern appearances around 250° to 280° (around the time of the winter solstice, as was the case with the theoretical data). The omitted records on this figure all occur between longitudes of 340° to 60°; the non-omitted records show a longitude gap between 345° and 40° except for two clear outliers with longitudes around 15°. These two predictions are from some of the latest known Almanacs which exhibit, as Sachs comments in his translations, some unusual and abbreviated terminology.<sup>229</sup> For example, given his transliteration of the (unbroken) Babylonian record:

23 gu<sub>4</sub>  
(MM 86.11.354, Obv. 2 (Almanac for SE 342))

Sachs, in his translation of this record, restores the text to say:

“On the 23<sup>rd</sup>, Mercury (will be visible for the first time in the east in Aries)”<sup>230</sup>

As the Appendix shows, no other Babylonian record of Mercury's first eastern visibility, observed or predicted, ever takes place in Aries. I have no doubt that these two records were in fact expected to be omitted visibilities and that this discrepancy is simply an artefact of the highly abbreviated terminology in these late texts.

Figure 7.3b shows that the omitted eastern disappearances all occur between longitudes of 350° and 90°, and that the non-omitted records demonstrate a longitude gap between approximately 0° and 60°.

Figures 7.3c again shows that Mercury's latitude at its first western appearance shows a longitude dependence similar to the theoretical values – it reaches its maximum latitude at a longitude of around 70° to 100° (around the time of the summer solstice). The figure shows that the omitted western visibilities all occur between longitudes of 165° to 230°, although three of the points occur at high enough latitudes that one would expect Mercury to actually be visible at these times; if these three values are not included, the omitted points all occur at similar longitudes between 190° and 230°. The non-omitted records show a longitude gap between 190° and 220°.

Figure 7.3d shows that the omitted western disappearances occur between longitudes of 190° and 235°, and that the non-omitted records have a longitude gap between 200° and 225°.

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<sup>229</sup> Sachs (1976).

<sup>230</sup> Sachs (1976), p. 382.



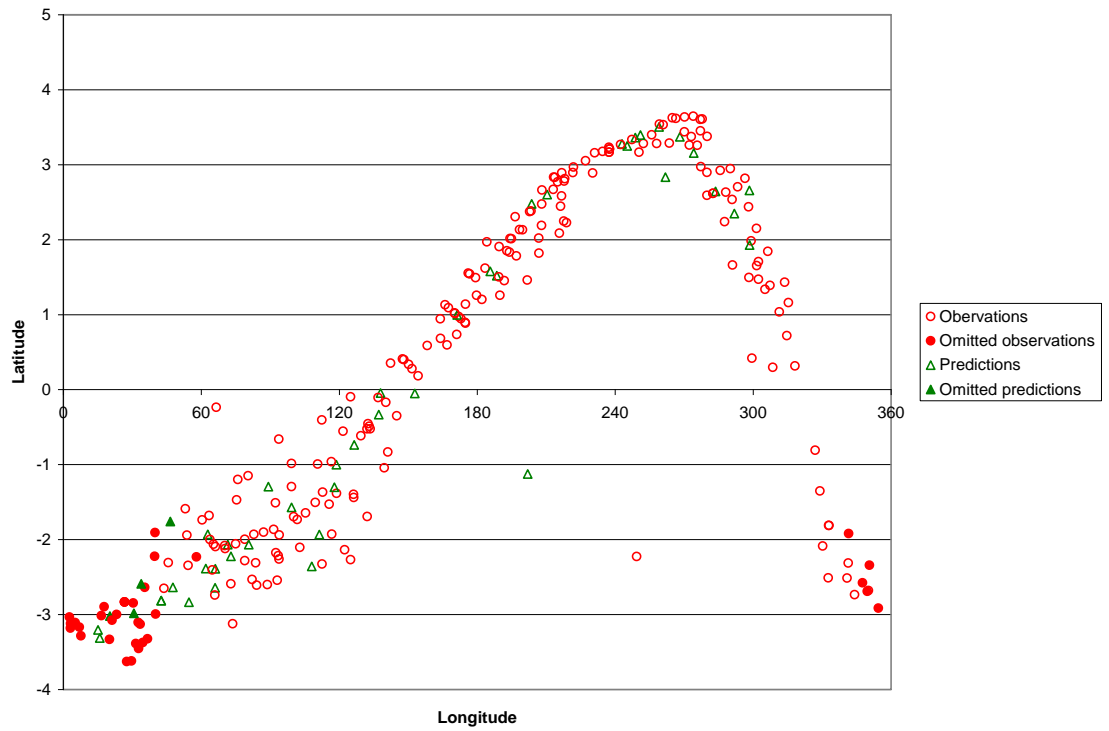


Figure 7.3a: Longitudes and latitudes of Mercury's first eastern appearances, using phenomenon dates from the Babylonian records

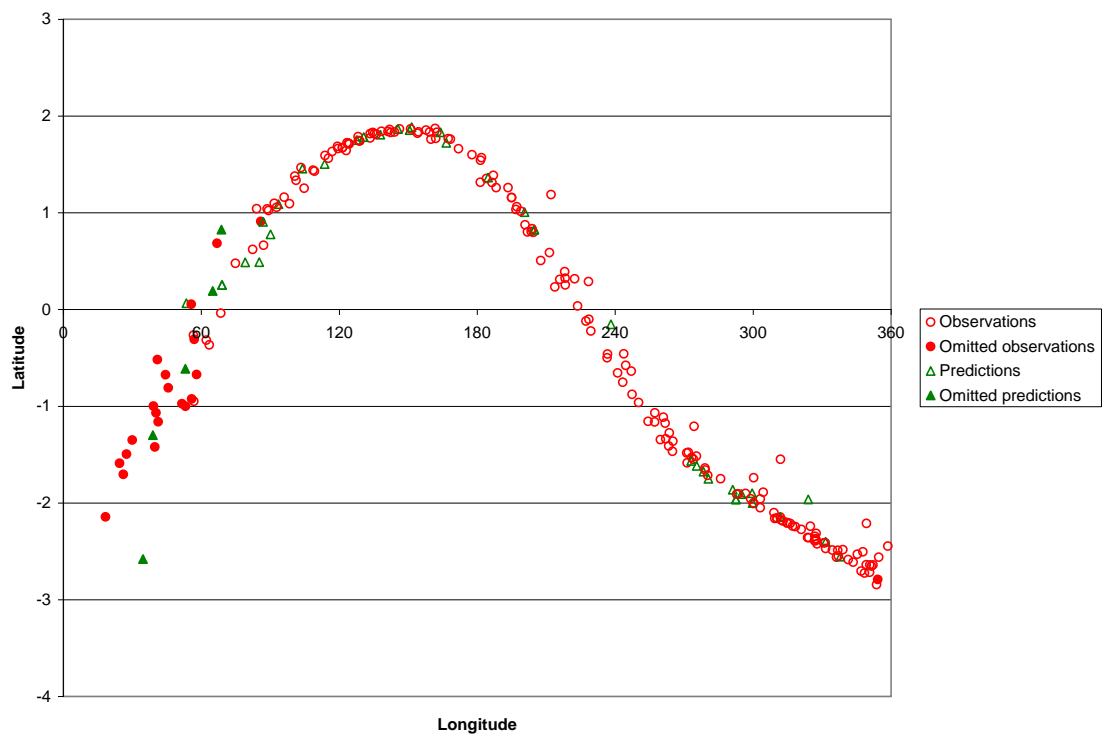


Figure 7.3b: Longitudes and latitudes of Mercury's eastern disappearances, using phenomenon dates from the Babylonian records

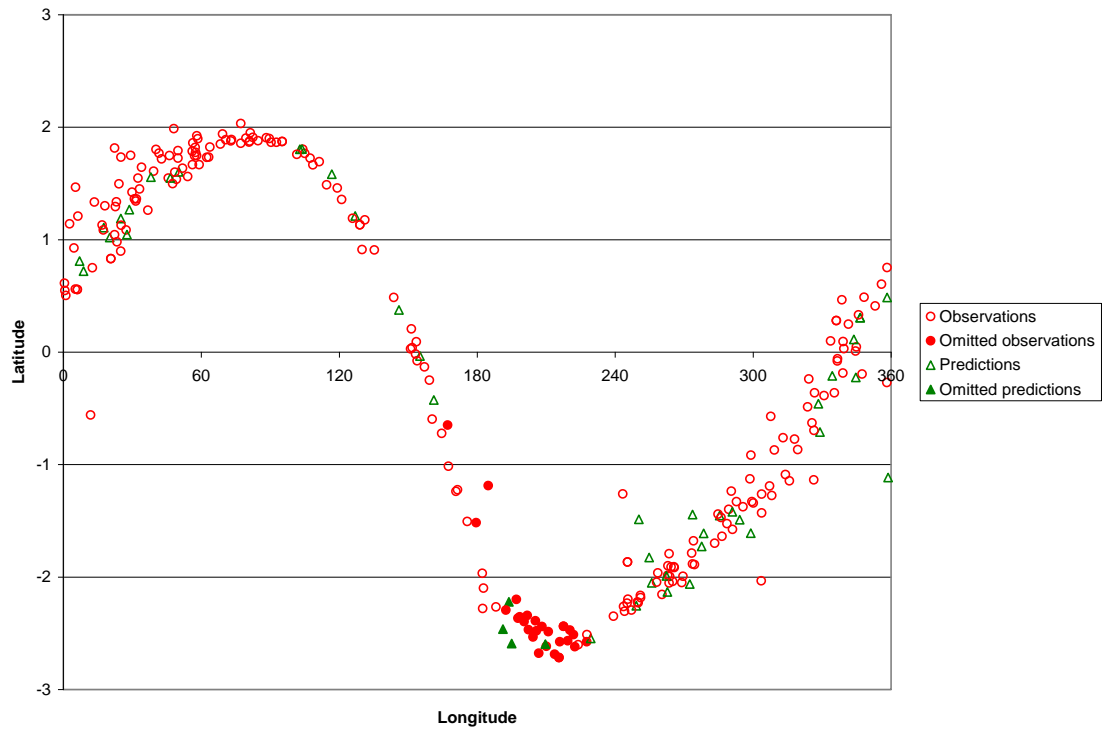


Figure 7.3c: Longitudes and latitudes of Mercury's first western appearances, using phenomenon dates from the Babylonian records

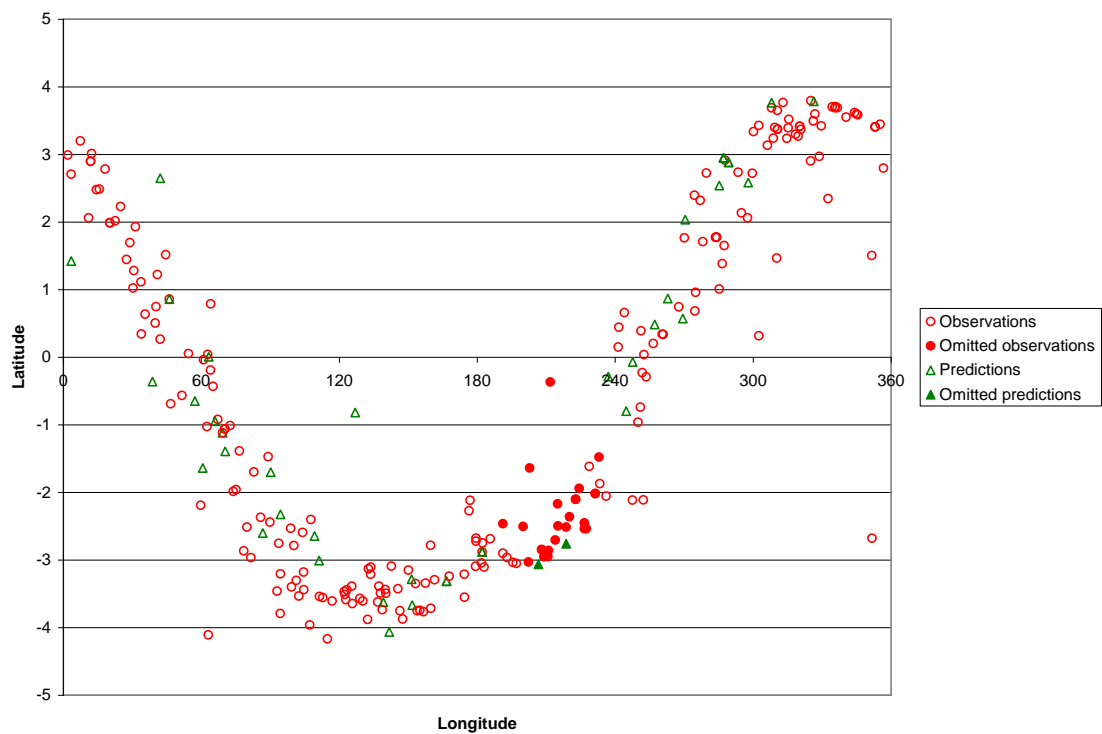


Figure 7.3d: Longitudes and latitudes of Mercury's western disappearances, using phenomenon dates from the Babylonian records

Table 7.1 summarises the results of these figures, to compare the longitude gaps found in the theoretical data (and Figures 7.2a-d), the *ACT* procedure texts, and the Babylonian non-mathematical records (and Figures 7.3a-d). It shows that the circumstances under which omitted phases occur in the non-mathematical texts (i.e. extremely negative latitude and particular times of the year) agree closely with theoretical expectations, and also with the mathematical schemes in *ACT*. The exact boundaries of the omitted regions differ slightly and, as one might expect, in the observational texts there is some overlap between the longitude boundaries of the omitted and non-omitted regions, compared with the precise boundaries of the theoretical schemes.

|                            | Theoretical longitude gaps - |              | Babylonian non-mathematical records - |                         |
|----------------------------|------------------------------|--------------|---------------------------------------|-------------------------|
|                            | Roughton's tables            | <i>ACT</i>   | Longitude gap                         | Omitted longitude range |
| First eastern visibilities | 320° to 55°                  | 10° to 50°   | 345° to 40°                           | 340° to 60°             |
| Last eastern visibilities  | 350° to 75°                  |              | 350° to 90°                           | 0° to 60°               |
| First western visibilities | 190° to 245°                 | 180° to 215° | 190° to 220°                          | 165° to 230°            |
| Last western visibilities  | 190° to 245°                 |              | 200° to 225°                          | 190° to 235°            |

**Table 7.1: a summary of the “omitted” longitude gaps for Mercury’s Greek-letter phenomena. The table compares the approximate longitude gaps found in Roughton’s theoretical phenomena dates (Figures 7.2a-d above), the *ACT* procedure texts, and the Babylonian records (Figures 7.3a-d above).**

The only particular discrepancies concern the fact that the *ACT* schemes tend to underestimate the omitted longitude ranges, compared with the ranges from the non-mathematical observations. For example, *ACT* says that the omitted longitude region for first eastern appearances should begin 10° into Aries. Yet, as we have seen, none of the non-mathematical texts ever record Mercury’s first eastern visibility in Aries, and only a very few of them record a first eastern visibility in Pisces. Equally, *ACT* says that the omitted longitude region for first western appearances should end 5° into Scorpio, yet, only an extremely small number of the non-mathematical texts record a first western appearance in Scorpio. This allows one to suggest that omitted dates in the Diaries (and subsequent excerpt texts) were not immediately derived from the same scheme as in *ACT*.

Interestingly, the longitude ranges of the non-mathematical *predictive* records agree much more closely with *ACT*. The longitude ranges are summarised for comparison in Table 7.2. As discussed previously, the two outlying predictions in Figure 7.3a with a longitude around 15° have not been included in this table.

|                            | Theoretical longitude gap - <i>ACT</i> | Babylonian non-mathematical predictions - |                         |
|----------------------------|--|---|-------------------------|
|                            |  | Longitude gap                             | Omitted longitude range |
| First eastern visibilities | 10° to 50°                             | 300° to 40°                               | 20° to 50°              |
| First western visibilities | 180° to 215°                           | 160° to 230°                              | 190° to 210°            |

**Table 7.2: a summary of the “omitted” longitude gaps for Mercury’s first eastern and western appearances. This table compares the longitude gaps found from the non-mathematical *predictions* with the *ACT* procedure texts.**

It is intriguing that the predictive texts’ longitude ranges agree so closely with *ACT* – much more so than the range of omitted longitudes from the observational texts. One might be

tempted to speculate that this is evidence of *ACT*-type methods at work in the compilation of the predictive texts. However, all the previous caveats about speculating from small amounts of data apply here – the predictive texts’ omitted longitude ranges are derived from only 4 records in each case. This is simply not enough to draw any conclusions.

### ***7.3 Lengths of Mercury’s periods of visibility and invisibility***

#### **7.3.1 Evidence from the Astronomical Cuneiform Texts**

In *ACT*, Neugebauer outlines the two major systems for computing Mercury’s motion. System  $A_1$  involves computing the dates of last visibilities from the dates and longitudes of the previous first visibilities, and System  $A_2$  involves computing the dates of first visibilities from the dates and longitudes of the previous disappearances.<sup>231</sup> These date and longitude “pushes” vary slightly between the different ephemeris texts, but they nevertheless provide a useful comparison with the analysis (in the following sections) of Mercury records in the non-mathematical texts.

Procedure texts 800a-d explicitly tabulate the longitude dependences of Mercury’s periods of visibility and invisibility in one variant of System  $A_1$ . In the following analyses I have used Neugebauer’s System  $A_1$  graphs showing the duration and longitude changes of Mercury’s eastern and western visibilities;<sup>232</sup> these are derived from the Procedure texts but use corrected values in place of the obvious scribal errors.<sup>233</sup>

For the duration and longitude changes of Mercury’s periods of invisibility, which are not explicitly tabulated in the procedure texts, Neugebauer attempted to derive the approximate relationships from the (much fewer) System  $A_2$  ephemeris texts. I have used his System  $A_2$  graphs showing the duration and longitude changes of Mercury’s invisibility following a disappearance in the west,<sup>234</sup> but unfortunately, he does not find enough evidence for a firm restoration of the pushes for Mercury’s invisibility following a disappearance in the east.

#### **7.3.2 Evidence from the non-mathematical astronomical texts**

Using the same database as above (shown in Appendix K), all cases were found where there were records of two immediately adjacent Mercury phenomena, i.e. the date of an appearance and the following disappearance, or a disappearance and the subsequent reappearance. This leads to the following numbers of record pairs for comparison:

Eastern appearance to disappearance:

109 observations (of which 16 are omitted)

24 predictions (of which 4 are omitted)

Eastern disappearance to western appearance:

88 observations (of which 23 include an omitted date)

19 predictions (of which 2 include an omitted date)

Western appearance to disappearance:

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<sup>231</sup> Neugebauer (1955), pp 288-299. There is also a much less well-understood System  $A_3$ , attested only in Procedure Text 816.

<sup>232</sup> Neugebauer (1955), p. 294 and 295.

<sup>233</sup> Neugebauer (1955), p. 364.

<sup>234</sup> Neugebauer (1955), p. 298 and 299.

111 observations (of which 11 are omitted)

19 predictions (of which 2 are omitted)

Western disappearance to eastern appearance:

127 observations (of which 23 include an omitted date)

20 predictions (of which 2 include an omitted date)

This is a smaller amount of data than in the above analysis of longitudes and latitudes because it requires finding pairs of adjacent Mercury phenomenon records with preserved dates, which is obviously less likely than finding individual such records. Also note that, for the pairs which involve one eastern and one western record and include an omitted date, the omitted record can naturally be either one of the pair. Which omitted points are eastern and which are western will be clear on the following figures, because of the strong longitude dependence of Mercury's eastern and western omitted visibilities as demonstrated in Figures 7.3a-d.

Figures 7.4a-d show the date differences, and Figures 7.5a-d show the longitude differences, between adjacent Mercury phenomena compared with Mercury's longitude at the time of the *earlier* phenomenon in each case (the same way in which the graphs in *ACT* are structured). The results from the observational and predictive Goal-Year type texts are shown, as before, along with the expected results from the *ACT* schemes where available.

Comparing 7.3a and c (from the previous section) with 7.4a and c shows that the non-mathematical records agree with our theoretical expectations in two ways. Firstly, Mercury's recorded periods of visibility are longer when its latitude at its appearance is higher. Secondly, the omitted phases occur when Mercury's period of visibility is at a minimum, as expected.

Comparing the non-mathematical records with the *ACT* values on each figure shows a good general agreement between the mathematical and the non-mathematical records of changes in longitude and date. Note in Figures 7.4a and c that, while the majority of the non-mathematical points fall very close to the *ACT* line, they are nearly all below it. In other words, the observed length of Mercury's period of visibility is virtually always smaller than the theoretical length from *ACT*. Equally, in Figure 7.4d the non-mathematical points fall close to the *ACT* line but nearly all *above* it, i.e. Mercury's period of invisibility is virtually always longer than the theoretical period from *ACT*. This result is logical if we assume that the *ACT* values are the ideal lengths of periods of visibility assuming perfect observing conditions. For the observational texts, weather effects can easily make observing conditions less than ideal, leading to Mercury's visibility period being shorter than expected (and the associated invisibility period being longer).

Figures 7.5a and c show that, similarly, the longitude changes across periods of visibility generally agree in *ACT* and in the non-mathematical texts. Yet there seem to be clear longitude regions where the dates from the non-mathematical texts result in a longitude difference which is almost always higher or lower than expected. At first glance this is rather surprising: Figures 7.4a and c showed that the number of *observed* days for which Mercury is visible is almost always lower than expected, so one might expect that a smaller number of days would always lead to a smaller change in longitude. However, this is not universally the case because Mercury's net longitude change during a phase of visibility or invisibility depends on how much of its motion is direct or retrograde.

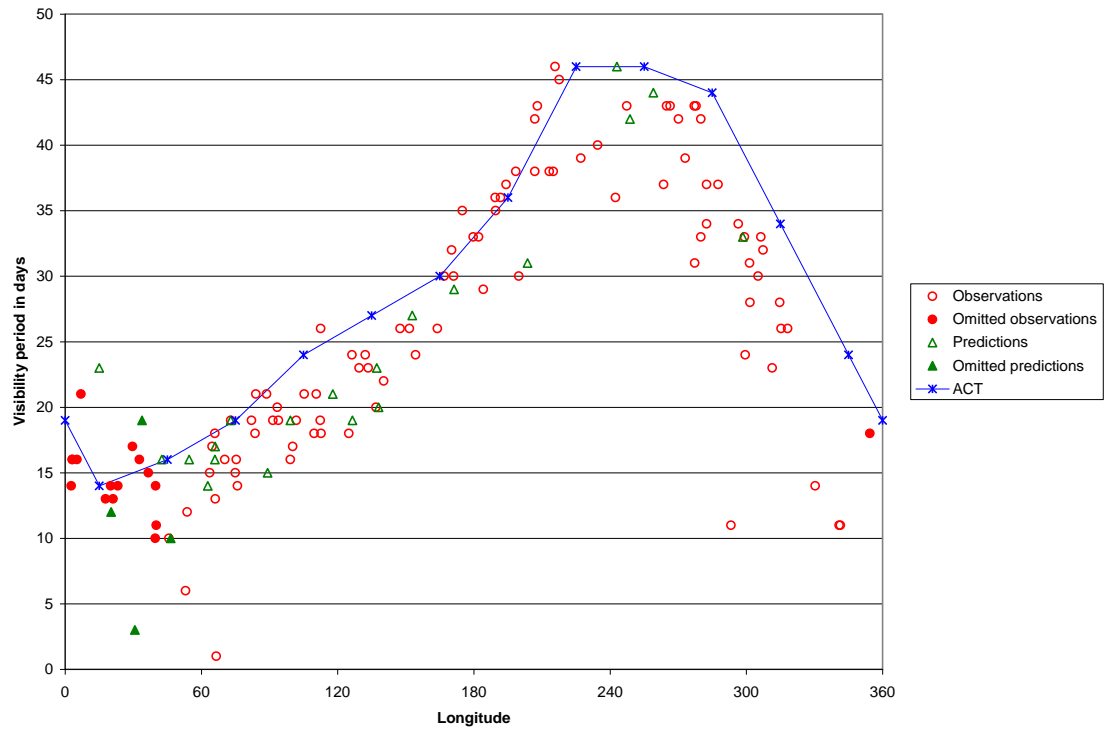


Figure 7.4a: Length of Mercury's eastern visibility in days, i.e. the number of days between a recorded first appearance and the following disappearance, plotted against Mercury's longitude at its appearance.

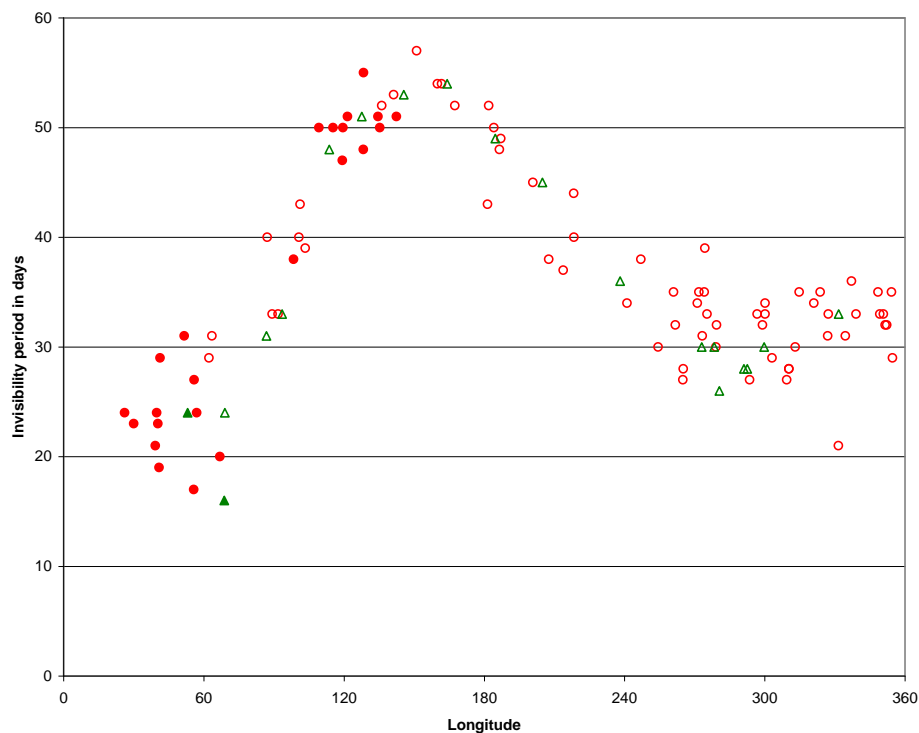


Figure 7.4b: Length of Mercury's invisibility in days, i.e. the number of days between an eastern disappearance and the following western appearance, plotted against Mercury's longitude at its disappearance.

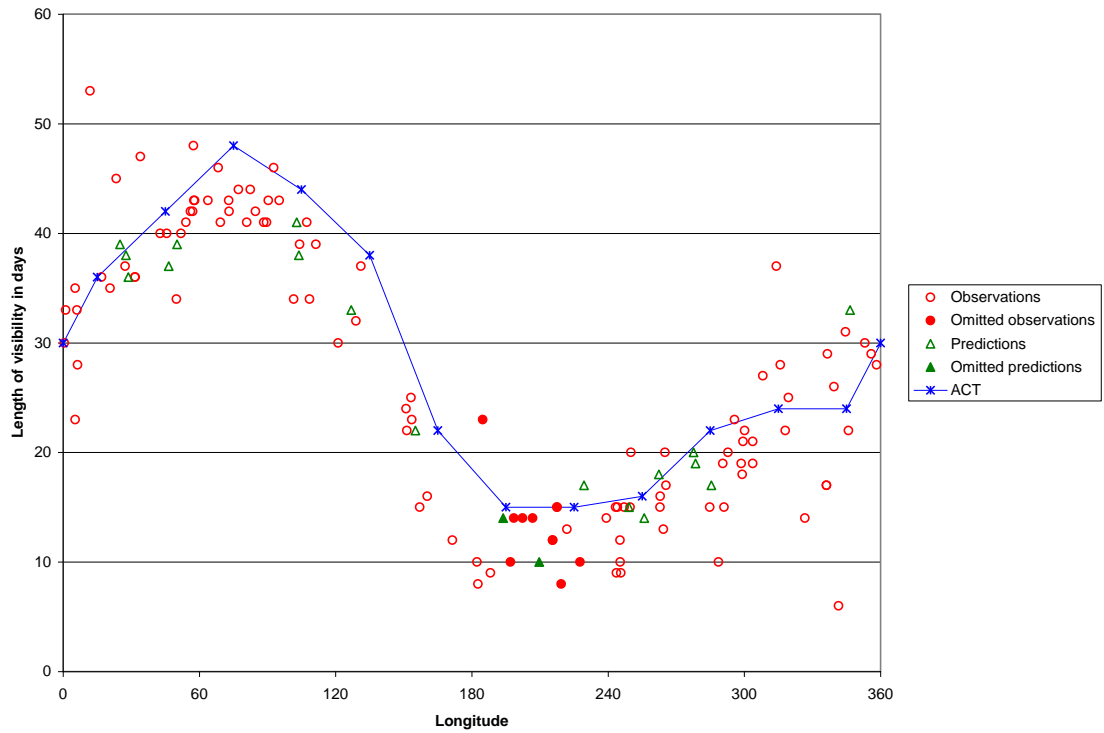


Figure 7.4c: Length of Mercury's western visibility in days, i.e. the number of days between a recorded first appearance and the following disappearance, plotted against Mercury's longitude at its appearance.

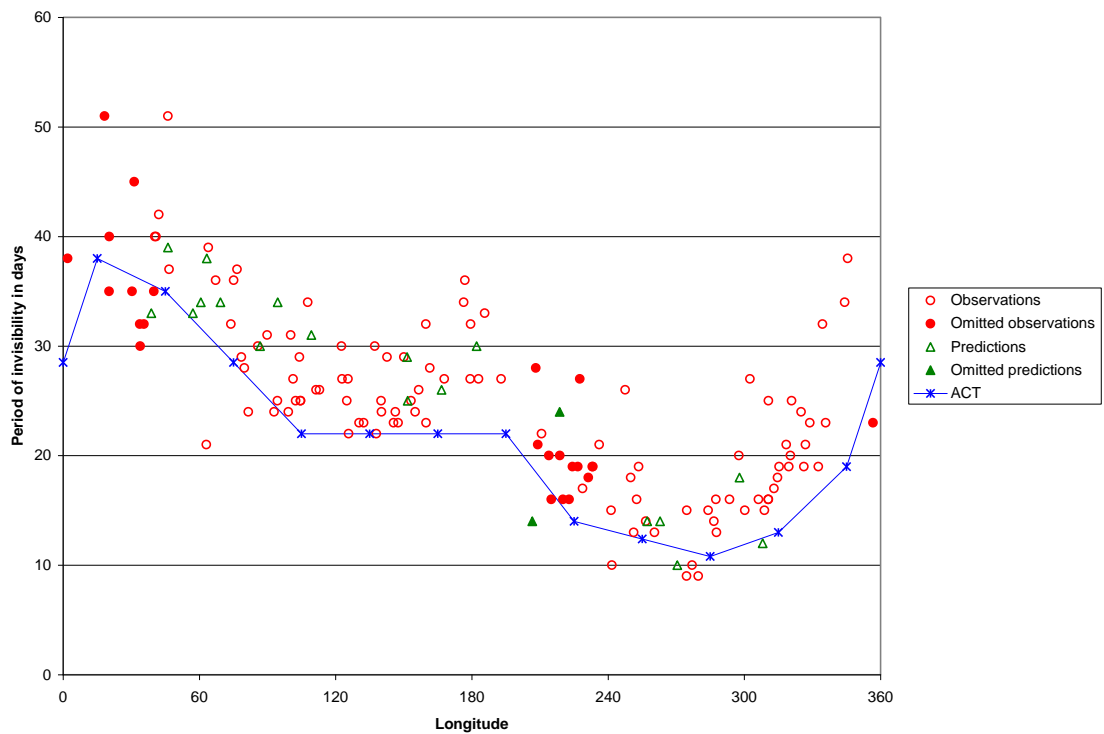


Figure 7.4d: Length of Mercury's invisibility in days, i.e. the number of days between a western disappearance and the following eastern appearance, plotted against Mercury's longitude at its disappearance.

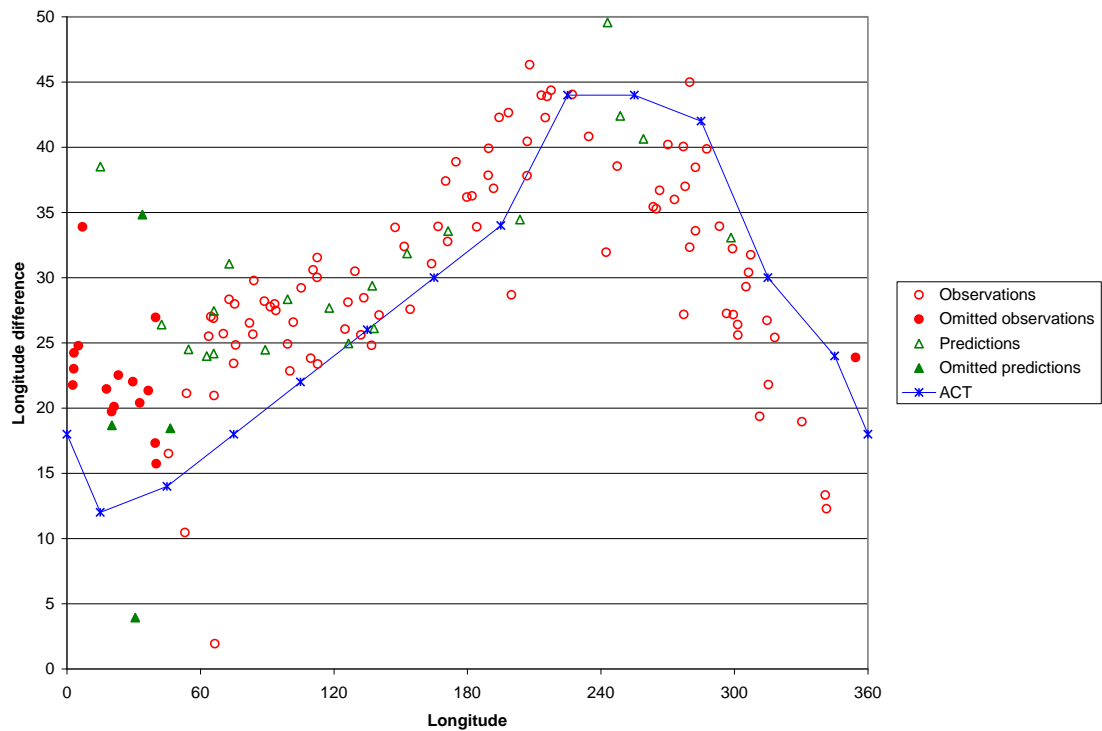


Figure 7.5a: The longitude change across Mercury's eastern period of visibility, i.e. the longitude difference between Mercury's appearance in the east and its subsequent disappearance, plotted against Mercury's longitude at its appearance.

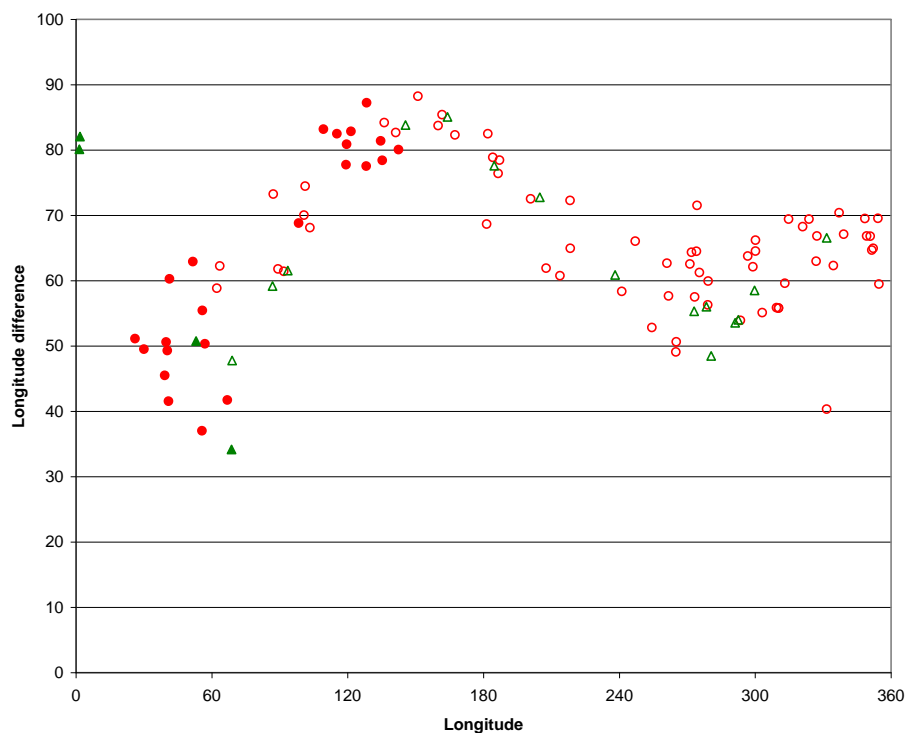


Figure 7.5b: The longitude change across Mercury's eastern period of invisibility, i.e. the longitude difference between Mercury's disappearance in the east and its subsequent appearance in the west, plotted against Mercury's longitude at its disappearance.



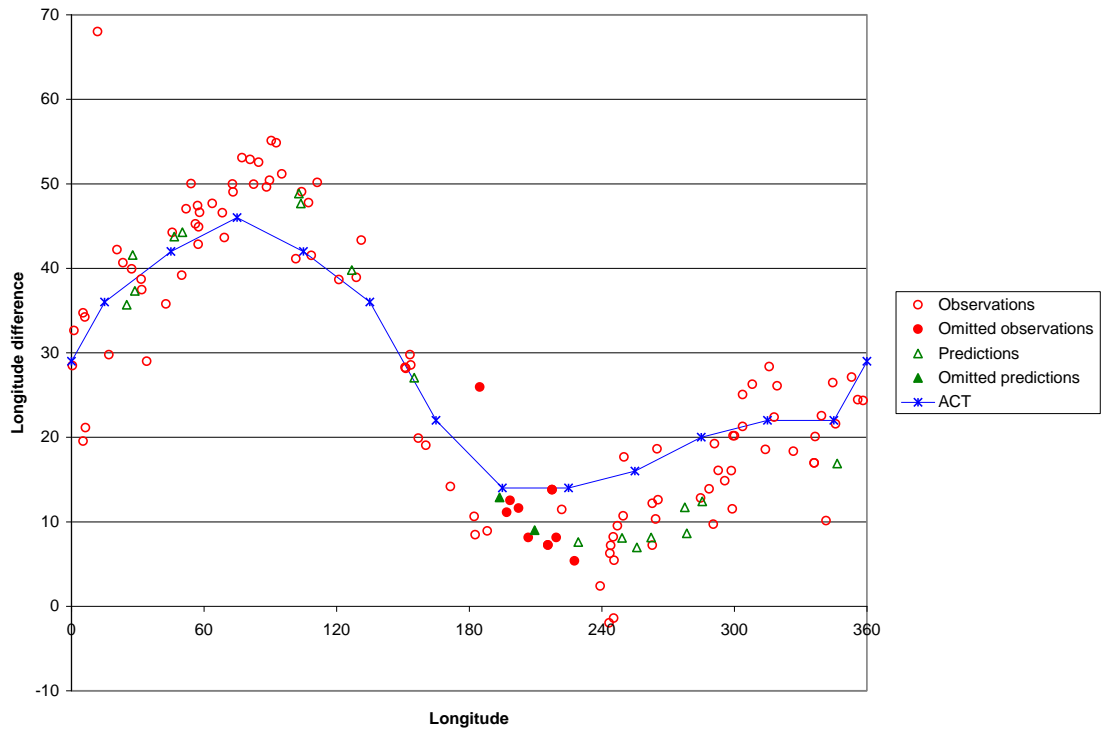


Figure 7.5c: The longitude change across Mercury's western period of visibility, i.e. the longitude difference between Mercury's appearance in the west and its subsequent disappearance, plotted against Mercury's longitude at its appearance.

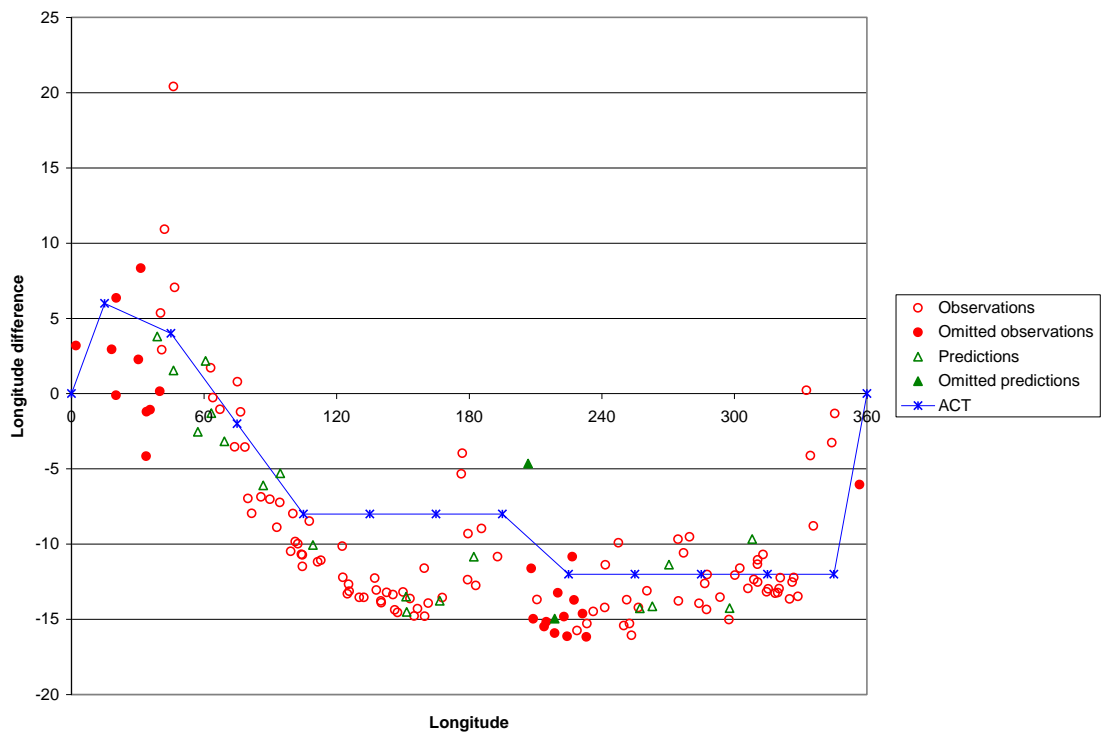
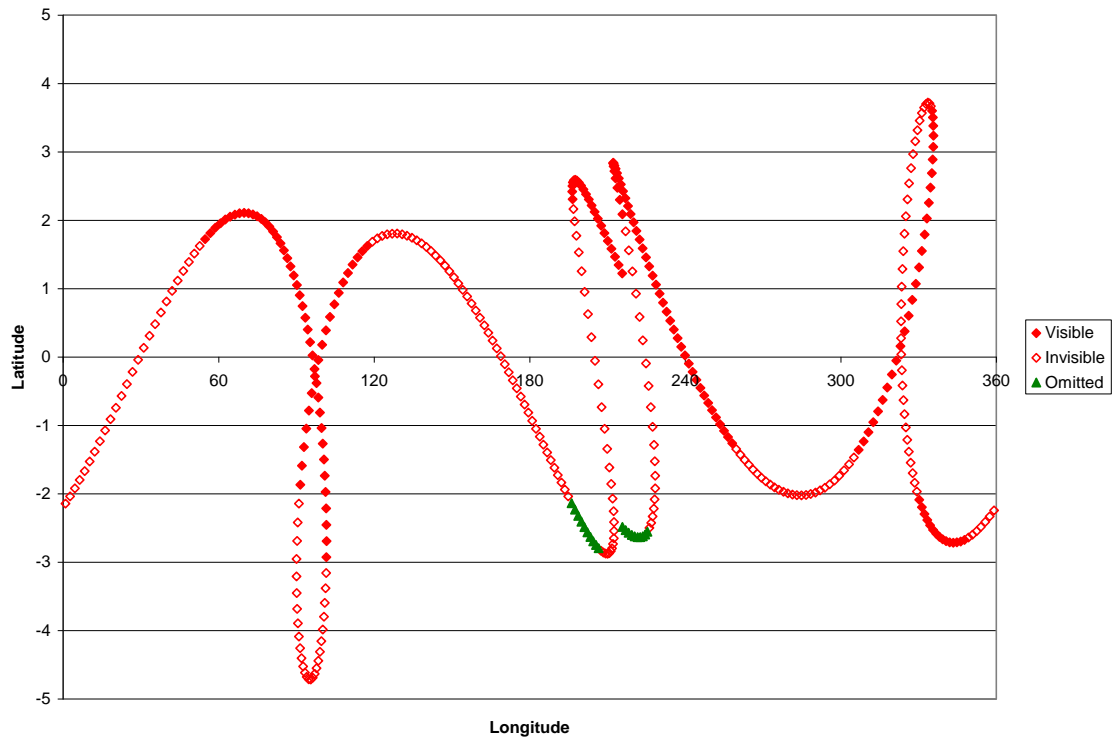


Figure 7.5d: The longitude change across Mercury's western period of invisibility, i.e. the longitude difference between Mercury's disappearance in the west and its subsequent appearance in the east, plotted against Mercury's longitude at its disappearance.



**Figure 7.6: Mercury’s longitude and latitude from October of -389 to November of -388, beginning and ending at a longitude of 215°. The regions where Mercury is visible or invisible from Babylon (according to *ADART* Vol. V No. 59) are marked.**

Figure 7.6 illustrates Mercury’s motion during a typical year, from October of -389 to November of -388, by plotting its longitude and latitude at midnight of each day according to JPL’s “Horizons” ephemerides. During this time Mercury’s longitude has moved through exactly 360°, so the figure chronologically begins and ends at 215° longitude. Conveniently, the text *ADART* Vol. V No. 59 has a completely preserved sequence of Mercury’s Greek-letter phenomena for this period, spanning the 13 months from Month VII of Artaxerxes II year 15 to Month VII of Artaxerxes II year 16. The figure illustrates the regions where, according to the Babylonian dates, Mercury was visible, invisible, or in an omitted phase.

Notice that Mercury sometimes appears or disappears at a point where its longitude is changing fast, and sometimes at a point where its longitude is hardly changing at all from day-to-day. Therefore, Mercury appearing a couple of days later than expected will sometimes have very little impact on the net longitude difference, and sometimes have a large effect.

Notice also that Mercury’s motion at its appearance can be either direct or retrograde. When Mercury becomes visible while moving retrograde, it is obvious that an observed first appearance a couple of days later than theoretically expected will lead to a *larger* net longitude difference between appearance and disappearance.

The comparison is clearer for Figure 7.5d, which shows Mercury’s longitude change during its invisibility phase following a disappearance in the west. Mercury is always retrograde during at least some of this phase, so the longitude difference between these two phenomena is nearly always negative, as the figure demonstrates. Notice that the longitude differences from the non-mathematical texts are mostly larger in magnitude than the *ACT*

values deduced by Neugebauer. This agrees with the conclusion from Figure 7.4d, which showed that Mercury's observed period of invisibility was generally longer than expected by *ACT*. If Mercury's motion is generally retrograde at these times then a longer period of invisibility will lead to a larger negative change in longitude.

## **7.4 Conclusions**

In this chapter I have outlined the fact that Mercury's visibility or invisibility on any particular date is a complex function, depending on the interaction of many related factors such as its latitude and elongation from the Sun, the ecliptic-horizon angle, and the observer's location and observing conditions. From this I have shown why some of Mercury's phases are impossible to see from Babylon, a phenomenon marked in the texts as "DIB" (passed by or omitted). Most of the researchers into Babylonian planetary theories do not discuss the mechanics of the omitted phases in any detail, despite the fact that the contributing factors of planetary latitude and elongation were known of as far back as Ptolemy's *Almagest*.

I have shown that the omitted phases in the non-mathematical texts occur at the expected points, where Mercury is at an extreme negative latitude and when the durations of its periods of visibility are lowest – in accordance with theoretical expectations, and with *ACT*'s ephemerides texts. Yet there is still the question of how observational texts such as the Astronomical Diaries could include dates of an event which is, by definition, not observable.

The evidence does not suggest that the omitted dates in the Diaries and other texts were taken directly from *ACT*, but I believe that the Babylonian astronomers had the tools to deduce dates and longitudes of the omitted phases using *ACT*-type methods from very early on in the Late Babylonian Period. That is, it would be simple to notice that Mercury did not appear for an entire eastern or western phase if one was employed to regularly watch out for it, and an interested observer could easily begin to deduce patterns for when this occurred by inspection of archived Diaries.

## Chapter 8

### Conclusions

#### *8.1 The relationships between records in the non-mathematical texts*

A major purpose of this work has been to understand the relationship between the records in the various types of non-mathematical astronomical text from the Late Babylonian Period. Chapter 2 compared records from the Astronomical Diaries and the Goal-Year Texts. The significantly high level of agreement between the records in these two texts confirms that it is extremely likely that the Goal-Year Texts' contents are excerpts from the Astronomical Diaries.

An important question, which had not previously been answered, was regarding the source of records in the non-mathematical predictive texts. In analysing this problem, I particularly looked at four potential solutions suggested by Sachs,<sup>235</sup> namely:

- i) that the predictive records derive from the ephemerides in *ACT*,<sup>236</sup>
- ii) that the predictive records derive from the observational records in the Goal-Year Texts,
- iii) that both of the above sources together were used in the production of the non-mathematical predictions,
- iv) that the Normal Star Almanacs used the Goal-Year Texts, and the Almanacs used the *ACT* ephemerides.

Chapter 2 considered the possibility that the predictions of planetary events could have been taken from the *ACT* ephemerides texts. However, a comparison of equivalent records in the various texts showed very clearly that this could not have been the case, because there was an extremely low level of agreement between dates of events in the ephemerides and the predictive texts. This means that solutions i) and iii) can be ruled out.

Chapter 5 compared records from the Normal Star Almanacs and the Almanacs. The small numbers of equivalent records consistently agree on the dates of events, strongly suggesting that the predictions the two types of text contain were derived from the same source. This rules out solution iv), or any other solution which would rely on the two types of text having their origins in different sources of records.

Therefore, we are left with solution ii) to analyse – that the predictive texts were compiled from the observational records in the Goal-Year Texts and, ultimately, derived from the Astronomical Diaries. Chapters 4, 5 and 6 considered this potential source of the non-mathematical predictions. In this theory, periods would be identified over which the planets' motion recurred. Excerpt texts such as the Goal-Year Texts, which consist of particular planets' observations for particular years, would then contain the observational "raw data" which could then be used to compile a predictive text for a specific year.

Chapter 4 examined planetary periods found in various Late Babylonian texts, and defined criteria against which we can compare the periods to determine how well they predict future events. Using theoretically calculated dates of planetary events to test the planetary periods, it was shown that the Goal-Year periods are virtually always those which best fit

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<sup>235</sup> Sachs (1948), pp. 288-289.

<sup>236</sup> Neugebauer (1955).

the criteria. The “date corrections” to the planetary periods were deduced (necessary due to the fact that periods over which the planets’ motion recur are rarely an exact number of Babylonian years).

It was also shown that, when using the Goal-Year periods to predict Normal Star passages, there would generally be no latitude difference between the planet- Normal Star distance at the time of a planetary passage, and the planet-Normal Star distance at the time of an equivalent planetary passage one Goal-Year period later. This is an important result because it would be extremely difficult to predict Normal Star passages effectively if the planetary periods did not demonstrate periodicity in the planet’s latitude as well as its longitude.

Chapter 5 identified several potential issues with using Goal-Year periods for predictions. In this chapter the issue of date corrections was addressed. The predictions in the Normal Star Almanacs and the Almanacs were compared with Goal-Year Text records. By analysing equivalent records (i.e. records of an event occurring in both a Goal-Year Text and a predictive text covering the same year as the goal year), it was possible to deduce date differences between records of equivalent events. If the observational data in the Goal-Year Texts was in fact intended to be raw data for making predictions for the goal year, then these date differences should match the theoretically derived date corrections from the previous chapter. It was shown that the date differences generally agreed very well with the theoretically derived date corrections. In addition, equivalent records of Normal Star passages which were compared almost always contained identical measurements of the planet-star distance – again, as expected from the theoretical data in the previous chapter. These two results are very strong evidence that the predictions in the Normal Star Almanacs and Almanacs were made using the Goal-Year Text records.

Chapter 6 addressed another one of Chapter 5’s potential issues with Goal-Year methods of prediction: the complications caused by the fact that Babylonian years are not a constant length. This implies that sometimes a “month shift” (changing the date of an observed record by  $\pm 1$  month to make a prediction) would be necessary when correcting the dates of records in the Goal-Year Text records to make predictions. This month shift is additional to, and entirely independent of, the date corrections deduced in the previous chapter. The dates of non-mathematical observational records (from the Diaries and the Goal-Year Texts) were compared with the dates of equivalent records from the predictive texts a Goal-Year period later. By analysing these dates it was shown that month differences between the observed and predicted events were always found at the points when they would be theoretically expected. This again lends strong support to the theory that the predictions in the Normal Star Almanacs and the Almanacs were derived from the Goal-Year Text records.

Further evidence to support to this relationship was found in Chapter 2: a comparison of records in the Astronomical Diaries of events which were not observed due to bad weather with records of equivalent events in the Normal Star Almanac or Almanac for the same year, shows that the dates of such events virtually always agree. This suggests that dates from the predictive texts were substituted into the Astronomical Diaries when bad weather prevented direct observation of an event.

In summary, analysis of records from the four major types of non-mathematical text: Astronomical Diary, Goal-Year Text, Normal Star Almanac and Almanac, suggests that they were closely related to each other. The evidence from the texts is consistent with the theory that the records were derived from each other as follows:

1. Observations of events -> written into Astronomical Diaries.
2. Astronomical Diary records for particular planets and years -> excerpted into Goal-Year Texts.
3. Goal-Year Text records -> rewritten chronologically, date corrections added or subtracted and month shifts applied as necessary, to make predictions for events of the goal year -> Almanacs and Normal Star Almanacs.
4. Almanacs and Normal Star Almanacs -> used to supply dates of events in Astronomical Diaries, when bad weather prevented observation.

## ***8.2 Other contributions to knowledge of Late Babylonian astronomy***

During the course of this study, a number of questions concerning various other aspects of Babylonian non-mathematical astronomy were also investigated and answered. In particular, analysing the data from the non-mathematical texts has allowed confirmation of results on several issues which had previously been mostly speculative. Additionally, the contents of considerable numbers of non-mathematical texts have become generally available (in the form of, for example, the *ADART* volumes) relatively recently and this has allowed the present study to verify other researchers' previous results by analysing a larger amount of data than was formerly available. These results will be outlined below.

Chapter 2 examined the contents of the Astronomical Diaries, showing that the planetary summaries at the end of each month were much more likely to include the "ideal" date of a planetary event rather than the observed date, where an ideal date was available. An analysis of parallel Astronomical Diaries covering the same time period showed that observers often disagree regarding measurements of time or distance when recording an astronomical event, and occasionally even disagree on the date of an event.

Chapter 3 examined the ways in which Normal Stars were used in the Normal Star Almanacs, as a direct comparison with Jones' work which analysed the usage of Normal Stars in observational texts.<sup>237</sup> This confirmed that the same Normal Stars were used in both types of text, and that the same patterns of "core" and "alternate" stars were found in each. However, as expected the Normal Star Almanacs do not include the full range of Normal Stars which are found in the observational texts. This is because many of the stars are only used in contexts outside the normal contents of a Normal Star Almanac; for example, exact positions of a planet's stationary point, or passages of the Moon by Normal Stars.

Also examined in Chapter 3 were the rare examples in the Almanacs and Normal Star Almanacs of predictions of stars' first and last visibilities (other than Sirius). Some of these stars have been identified, but others have not. By analysing the stars' rising and setting dates, and comparing these dates with Babylonian star lists such as those in *Enūma Anu Enlil*, *MUL.APIN*, etc., the probable identity of each of the stars was suggested.

Chapter 3 also investigated planetary records involving zodiacal signs. Firstly, analysing the dates on which planets are recorded as reaching new zodiacal signs confirmed that the lengths of the zodiacal signs were always around 30° of longitude. Secondly, analysis of the

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<sup>237</sup> Jones (2004)

planetary records concerning zodiacal signs demonstrated the important result that the Babylonian terminology SAG (“beginning”) and TIL (“end”) of a zodiacal sign was used to refer to about the first and last  $5^\circ$ , respectively, of the zodiacal sign.

Chapter 6 examined the occasional remarks found in the planetary sections of the Goal-Year Texts which did not relate to the planet’s observations year. These fell into two general categories:

- i) a record of a planetary event from the Month XII<sub>(2)</sub> immediately previous to the observations year or the Month I immediately following the observations year, or
- ii) a remark that the observations year, or the year previous to the observations year, was intercalary.

It was shown that, as expected, records in category i) were those for which, once the necessary date correction had been applied, the equivalent event would fall within the goal year. Events in category ii) were initially assumed to be connected with keeping track of the required month shifts, but this was shown not to be the case. The remarks are not only found at points where a month shift would be necessary, and it was shown that remarks of this type occur much too infrequently to have been included for *every* intercalary month. Ultimately one is left to speculate that the infrequent nature of these remarks is a consequence of different Babylonian scribes employing different methods to keep track of the distribution of intercalary months.

Chapter 7 investigated the factors which affect Mercury’s visibility, and showed how and why the interaction of these factors leads to the occurrence of “omitted” visibility phases. By analysing records of Mercury’s appearance or disappearance from the non-mathematical texts, two important results were found:

- i) Mercury’s latitude at the time of its first appearance is strongly correlated with its longitude (and, by extension, the time of year). As expected, the omitted visibility phases occur when Mercury’s latitude is at a minimum. The patterns of longitude-latitude dependence from the non-mathematical texts agree with the theoretically-derived patterns, and also with the procedure texts in *ACT*.
- ii) The length of time for which Mercury remains visible or invisible is also strongly correlated with its longitude, and the time of year. As expected, the omitted visibility phases occur when the length of time Mercury is expected to remain visible is at a minimum, and the length of time Mercury is expected to remain invisible is at a maximum. These patterns again agree with the patterns derived from the procedure texts in *ACT*.

In conclusion, this study represents a significant advancement in our understanding of Late Babylonian non-mathematical astronomy. In particular, the interconnectedness of the various non-mathematical texts has been demonstrated. Analysis of the non-mathematical records has also enhanced many other aspects of our general awareness and appreciation of the Late Babylonian astronomers’ methods.

## Appendices

### *Appendix A: the contents of planetary summaries from the Astronomical Diaries*

| Diary<br>year | Month               | Contents of planetary summaries  |
|---------------|---------------------|--|
| -453          | X                   | Summary includes observed date   |
| -418          | I                   | Summary includes observed date   |
| -373          | VII                 | Summary includes observed date   |
| -366          | IV                  | Ideal date given for event - summary includes observed date            |
| -324          | II                  | Summary includes observed date   |
| -309          | V                   | Summary includes event date - unclear whether ideal or observed        |
| -308          | V                   | Summary includes event date - unclear whether ideal or observed        |
| -300          | VII                 | Summary includes event date - unclear whether ideal or observed        |
| -293          | II                  | Ideal date given for event - summary includes observed date            |
| -287          | I                   | Summary includes observed date   |
| -286          | VII                 | Summary includes "around the" date - unclear whether ideal or observed |
| -284          | VII                 | Summary includes event date - unclear whether ideal or observed        |
| -284          | VII                 | Ideal date given for event - summary includes "on the" ideal date      |
| -284          | VIII, XI            | Summary includes observed date   |
| -283          | VII                 | Ideal date given for event - summary includes observed date            |
| -273          | XII                 | Ideal date given for event - summary includes "around the" ideal date  |
| -266          | II                  | Summary includes "around the" observed date                            |
| -264          | VII                 | Summary includes "around the" date - unclear whether ideal or observed |
| -261          | VII                 | Summary includes "around the" observed date                            |
| -261          | IX                  | Ideal date given for event - summary includes observed date            |
| -260          | VI                  | Summary includes "around the" date - unclear whether ideal or observed |
| -257          | IV                  | Summary includes "around the" date - unclear whether ideal or observed |
| -255          | VI, VI <sub>2</sub> | Summary includes "around the" date - unclear whether ideal or observed |
| -255          | I                   | Summary includes "around the" observed date                            |
| -254          | IX                  | Summary includes "around the" date - unclear whether ideal or observed |
| -253          | VI                  | Summary includes "around the" observed date                            |
| -251          | XII                 | Summary includes "around the" observed date                            |
| -251          | VII                 | Summary includes observed date   |
| -251          | XII                 | Summary includes "around the" last seen date (not last visibility)     |
| -249          | IX                  | Ideal date given for event - summary includes "around the" ideal date  |
| -249          | IX, XII             | Summary includes "around the" observed date                            |
| -247          | VIII                | Summary includes "around the" date - unclear whether ideal or observed |
| -246          | I                   | Ideal date given for event - summary includes "around the" ideal date  |
| -246          | VI                  | Summary includes "around the" observed date                            |
| -241          | II                  | Summary includes "around the" date - unclear whether ideal or observed |
| -237          | IV                  | Ideal date given for event - summary includes "around the" ideal date  |
| -237          | V                   | Summary includes "around the" observed date                            |
| -234          | VII                 | Summary includes "around the" observed date                            |
| -234          | XI                  | Summary includes "around the" date - unclear whether ideal or observed |
| -232          | VIII                | Ideal date given for event - summary includes "around the" ideal date  |
| -232          | VIII, X             | Summary includes "around the" observed date                            |
| -232          | XI                  | Summary includes "around the" date - unclear whether ideal or observed |
| -230          | I                   | Ideal date given for event - summary includes "around the" ideal date  |
| -230          | VI                  | Summary includes "around the" date - unclear whether ideal or observed |
| -226          | II, III             | Summary includes observed date   |
| -225          | III, IV             | Summary includes "around the" observed date                            |



| Diary<br>year | Month        | Contents of planetary summaries  |
|---------------|--------------|--|
| -225          | IV           | Summary includes observed date   |
| -222          | X            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -218          | VII          | Summary includes "around the" observed date  |
| -218          | XI           | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -209          | II           | Ideal date given for event - summary includes "on the" ideal date  |
| -209          | III, IV      | Summary includes observed date   |
| -207          | I, II        | Summary includes event date - unclear whether ideal or observed  |
| -204          | I            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -203          | VIII         | Summary includes event date - unclear whether ideal or observed  |
| -202          | V, VII       | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -198          | IX           | Summary includes "around the" observed date  |
| -197          | VII, VIII    | Ideal date given for event - summary includes "around the" ideal date                                      |
| -197          | XII          | Ideal date given for event - summary includes "around" a date which is neither the observed nor ideal date |
| -195          | IX           | Summary includes "around the" observed date  |
| -194          | III          | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -193          | VII          | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -193          | VIII         | Summary includes observed and ideal date   |
| -191          | IV, VIII     | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -190          | II           | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -190          | III          | Summary includes observed date   |
| -189          | II           | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -187          | XI           | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -186          | XII          | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -186          | X, XI        | Summary includes observed and ideal date   |
| -185          | XII          | Summary includes observed and ideal date   |
| -183          | II           | Summary includes observed and ideal date   |
| -182          | I            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -180          | XII          | Summary includes event date - unclear whether ideal or observed  |
| -178          | XII          | Summary includes "around the" observed date  |
| -176          | V            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -170          | II           | Ideal date given for event - summary includes "around the" ideal date                                      |
| -170          | V            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -168          | V            | Ideal date given for event - summary includes "around the" ideal date                                      |
| -168          | V, VI        | Summary includes "around the" observed date  |
| -168          | VIII         | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -165          | V            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -164          | VII          | Ideal date given for event - summary includes "around the" ideal date                                      |
| -164          | XII          | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -163          | VIII, X, XII | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -162          | V            | Summary includes "around the" last seen date (not last visibility)   |
| -161          | I, V         | Summary includes "around the" observed date  |
| -161          | I, II,       | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -160          | XI           | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -158          | V            | Summary includes "around the" observed date  |
| -156          | I            | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -155          | IV           | Summary includes "around the" observed date  |
| -153          | V            | Summary includes "around the" observed date  |
| -149          | VII          | Summary includes "around the" observed date  |
| -146          | IX           | Summary includes "around the" date - unclear whether ideal or observed                                     |
| -146          | X            | Ideal date given for event - summary includes "around the" ideal date                                      |
| -146          | X            | Summary includes "around the" observed date  |
| -144          | VI           | Summary includes "around the" date - unclear whether ideal or observed                                     |

| Diary<br>year | Month                     | Contents of planetary summaries   |
|---------------|---------------------------|---|
| -144          | VII                       | Ideal date given for event - summary includes "around the" ideal date                     |
| -143          | V                         | Summary includes "around the" date - unclear whether ideal or observed                    |
| -143          | VI                        | Ideal date given for event - summary includes "around the" ideal date                     |
| -141          | VI, VI <sub>2</sub> , XII | Summary includes "around the" date - unclear whether ideal or observed                    |
| -141          | VII                       | Ideal date given for event - summary includes "around the" ideal date                     |
| -141          | VI <sub>2</sub>           | Summary includes "around the" observed date   |
| -140          | I                         | Summary includes "around the" observed date   |
| -140          | IV                        | Summary includes observed date  |
| -140          | IX                        | Ideal date given for event - summary includes "around the" ideal date                     |
| -140          | X                         | Summary includes "around the" date - unclear whether ideal or observed                    |
| -137          | II, VIII, X               | Summary includes "around the" observed date   |
| -136          | VII                       | Summary includes "around the" observed date   |
| -136          | X                         | Summary includes "around the" last seen date (not last visibility)                        |
| -133          | XII                       | Summary includes "around the" date - unclear whether ideal or observed                    |
| -132          | VII, XII                  | Summary includes observed date  |
| -132          | VII, X                    | Summary includes "around the" date - unclear whether ideal or observed                    |
| -126          | VIII                      | Summary includes "around the" date - unclear whether ideal or observed                    |
| -125          | I                         | Summary includes "around the" last seen date (not last visibility)                        |
| -125          | V                         | Summary includes "around the" date - unclear whether ideal or observed                    |
| -124          | II, IX, X                 | Summary includes "around the" date - unclear whether ideal or observed                    |
| -124          | III                       | Summary includes "around the" observed date   |
| -123          | III                       | Ideal date given - Summary includes "around the" date - unclear whether ideal or observed |
| -122          | II, XII                   | Summary includes "around the" date - unclear whether ideal or observed                    |
| -122          | VI <sub>2</sub>           | Summary includes "around the" observed date   |
| -120          | V                         | Summary includes "around the" date - unclear whether ideal or observed                    |
| -119          | I                         | Ideal date given for event - summary includes "around the" ideal date                     |
| -119          | II                        | Summary includes "around the" date - unclear whether ideal or observed                    |
| -118          | I, VII                    | Ideal date given for event - summary includes "around the" ideal date                     |
| -117          | VIII                      | Summary includes "around the" date - unclear whether ideal or observed                    |
| -111          | I                         | Ideal date given for event - summary includes "around the" ideal date                     |
| -111          | I                         | Summary includes "around the" observed date   |
| -110          | V                         | Summary includes "around the" observed date   |
| -110          | V                         | Summary includes "around the" date - unclear whether ideal or observed                    |
| -109          | VIII                      | Summary includes "around the" date - unclear whether ideal or observed                    |
| -108          | IV                        | Summary includes "around the" last seen date (not last visibility)                        |
| -108          | V                         | Ideal date given for event - summary includes "around the" ideal date                     |
| -108          | VII                       | Summary includes "around the" date - unclear whether ideal or observed                    |
| -107          | XI                        | Summary includes "around the" date - unclear whether ideal or observed                    |
| -105          | I, V                      | Summary includes "around the" observed date   |
| -105          | III, VI                   | Summary includes observed date  |
| -103          | II                        | Summary includes "around the" date - unclear whether ideal or observed                    |
| -93           | IV, V                     | Summary includes "around the" date - unclear whether ideal or observed                    |
| -90           | X                         | Summary includes "around the" observed date   |
| -90           | XI                        | Summary includes "around the" date - unclear whether ideal or observed                    |
| -87           | XII <sub>2</sub>          | Ideal date given for event - summary includes "around the" ideal date                     |
| -87           | VI, XII                   | Summary includes "around the" date - unclear whether ideal or observed                    |
| -85           | X                         | Ideal date given for event - summary includes "around the" ideal date                     |
| -77           | III, V                    | Ideal date given for event - summary includes "around the" ideal date                     |
| -77           | II, IV, XI                | Summary includes "around the" observed date   |
| -77           | III, VII                  | Summary includes "around the" date - unclear whether ideal or observed                    |

***Appendix B: a comparison of overlapping records from the Diaries and the Goal-Year Texts***

| Text No.     |              |                       | Observations<br>year (SE) |  |
|--------------|--------------|-----------------------|---------------------------|--|
| GYT<br>Diary | 31<br>-247 B | Obv.' 3-4<br>Rev.' 4' | 64                        | Around until the 19th, when Jupiter became stationary to the east, it became stationary behind the 4 rear ones of Sagittarius<br>The 19th, Jupiter became stationary to the east, it [became stationary] behind the 4 (stars) of the breast of [...]                   |
| GYT<br>Diary | 49<br>-226   | Obv.' 3<br>Rev.' 11   | 85                        | [Jupiter,] while moving back to the east, was 4 ½ cubits below θ Leonis<br>[21-23] first part Jupiter, while moving back to the east, was 4 cubits [below θ] Leonis  |
| GYT<br>Diary | 60<br>-198 C | Obv.' 3<br>Rev.' 2    | 113                       | Around the 12th, Jupiter's last appearance in Capricorn<br>Around the 12th, Jupiter's last appearance in Capricorn   |
| GYT<br>Diary | 63<br>-195   | Obv. 1<br>'Obv. 23'   | 116                       | Around until the 26th, when Jupiter became stationary to the east, it became stationary 2 ½ cubits [...]<br>Around the 26th, [when] Jupiter [became stationary to the east, it became stationary 2 ½ cubits ...]   |
| GYT<br>Diary | 85<br>-146   | 'Obv.' 2'<br>Rev.' 3  | 165                       | [... when it became station]ary in [... in became stationary] ½ cubit in front of μ Geminorum, 8 fin[g]ers ...]<br>[18-20th ...] when Jupiter became stationary to the west, it became stationary 6 fingers in front of μ Geminorum, 8 fingers high to the north [...] |
| GYT<br>Diary | 20<br>-201 B | Obv. 20<br>Obv. 4     | 110                       | Night of the 2nd last part Venus was 2 cubits above α Scorpii<br>Night of the 3rd last part Venus was 3 cubits above α Scorpii   |
| GYT<br>Diary | 20<br>-201 B | Obv. 20<br>Rev. 8     | 110                       | Night of the 14th last part Venus was 2 cubits above θ Ophiuchi<br>Night of the 14th last part Venus was 2 cubits above θ Ophiuchi   |
| GYT<br>Diary | 22<br>-197 B | Obv. 10'<br>Obv. 18   | 114                       | [...] Venus' first appearance in the west in Sagittarius; [...] (ideal) first on the 22nd<br>The 25th, Venus' first appearance in the east in Sagittarius; it was small, rising of Venus to sunrise: 9°; (ideal) first on [the 22nd ...]                               |

| Text No. |        |             | Observations<br>year (SE) |  |
|----------|--------|-------------|---------------------------|--|
| GYT      | 35     | Obv. 11     | 132                       | The 30th, Venus' first appearance in the east in Pisces ..... (ideal) first appearance on the 29th   |
| Diary    | -179 E | 'Rev.' 12'  |                           | Around the 29th, Venus' [first appearance] in the east in Ar[ies ...]  |
| GYT      | 39     | Obv. 18     | 136                       | Night of the 9th last part Venus was 1 cubit above $\theta$ Ophiuchi   |
| Diary    | -175 B | Obv.' 9     |                           | [8th-9th] last part Venus was 1 cubit above $\theta$ Ophiuchi  |
| GYT      | 44     | 'Obv.' 11'  | 147                       | Night of the 21st last part Venus was 2/3 cubit below $\gamma$ Virginis  |
| Diary    | -164 B | 'Obv.' 9'   |                           | Night of the 21st last part Venus was [2/3 cubit] below $\gamma$ Virginis  |
| GYT      | 45     | Obv.' 9     | 150                       | 1 cubit <sup>2</sup> [...] $\mu$ Geminorum   |
| Diary    | -161 A | 'Obv.' 15'  |                           | [Night of the 2]5th first part Venus was 1 cubit above $\mu$ Geminorum   |
| GYT      | 45     | Obv.' 13    | 150                       | [...] 2 fingers above $\beta$ Virginis, Venus [having passed] 2 fingers to the east  |
| Diary    | -161 A | 'Obv. 4'    |                           | [... Ve]nus was 2 fingers above $\beta$ Virginis, Venus having passed 2 fingers to the east  |
| GYT      | 54     | Obv.' 13-14 | 167                       | The 17th, Venus' [first appearance in the west in ...] (ideal) first on the 15th <sup>2</sup>  |
| Diary    | -144   | 'Obv. 6'    |                           | [Around the 17th <sup>2</sup> ] Venus' first appearance in the west in the end of Virgo; it was small, sunset to setting of Venus: 10° [...] |
| GYT      | 54     | Obv.' 14    | 167                       | Night of the 10th first part Venus was 3 cubits below $\beta$ Capricorni   |
| Diary    | -144   | Rev.' 28-29 |                           | Night of the 10th first part Venus was 3 cubits below $\beta$ Cap[ricorni]   |
| GYT      | 58     | Obv.' 13    | 174                       | [Ni]ght of the 1st first part Venus was 4 fingers below $\alpha$ Virginis, Venus ...   |
| Diary    | -137 A | 'Rev.' 12'  |                           | The 1st, first part Venus was 5 fingers below $\alpha$ Virginis, Venus being 2 fingers back to the west                                      |
| GYT      | 58     | Obv.' 11    | 174                       | [...] 2/3 cubit [above] $\alpha$ Leonis, Venus having passed 4 fingers to the east   |
| Diary    | -137 B | 'Rev.' 2'   |                           | [Night of the 7th first part Ven]us was 2/3 cubit above $\alpha$ Leonis.   |
| GYT      | 58     | Obv.' 12    | 174                       | [...] 4 1/2 cubits [below] $\theta$ Leonis   |
| Diary    | -137 B | 'Rev.' 11'  |                           | [Night of the 22nd first part Venus was] 4 1/2 cubits [below $\theta$ Leonis]  |

## Appendix B

| Text No. |        |              | Observations<br>year (SE) |   |
|----------|--------|--------------|---------------------------|---|
| GYT      | 63     | Obv. 11      | 179                       | [...] Venus was 1 cubit 4 fingers below $\alpha$ Leonis   |
| Diary    | -132 B | Obv. 3       |                           | Night of the 3rd last part Venus was 1 cubit 4 fingers below $\alpha$ Leonis  |
| GYT      | 63     | Obv. 13      | 179                       | [...] Venus was $\frac{1}{2}$ cubit [below $\gamma$ ] Virginis, Venus having passed 2 fingers to the east                                 |
| Diary    | -132 B | Rev. 3       |                           | Night of the 15th last part Venus was $\frac{1}{2}$ cubit below $\gamma$ Virginis, Venus having passed 4 <sup>2</sup> fingers to the east |
| GYT      | 69     | Obv. 16      | 186                       | Night of the 10[+x first part Venus was] 1 <sup>2</sup> $\frac{1}{2}$ cubits [below $\eta$ Tau]ri   |
| Diary    | -125 B | 'Rev.' 6'    |                           | [26-7th] first part Venus was 1 $\frac{1}{2}$ cubits below $\eta$ Tauri   |
| GYT      | 70     | 'Obv.' 6'    | 188                       | [...] first part Venus was 3 [cubits] below $\beta$ Librae  |
| Diary    | -123 B | 'Flake' 7'   |                           | Night of the 16th first part Venus was 3 $\frac{1}{2}$ cubits below $\beta$ Librae ...  |
| GYT      | 71     | 'Obv. 9'     | 190                       | Night of the 15th first part Venus was 1 $\frac{1}{2}$ cubits below $\gamma$ Virginis   |
| Diary    | -121   | 'Obv. 10'    |                           | Night of the 13th ...] Venus was 1 $\frac{2}{3}$ cubits [below $\gamma$ ] Virginis  |
| GYT      | 73     | Obv. 27'-28' | 194                       | Night of the 25th first part Venus was 2 <sup>2</sup> cubits <sup>2</sup> below $\eta$ Tauri  |
| Diary    | -117 B | 'Rev.' 16'   |                           | Night of the 26th first part Venus was 1 cubit below $\eta$ Tauri   |
| GYT      | 77     | Obv. 5       | 199                       | Night of the 15th first part Venus [...]; I did not see $\alpha$ Scorpïi  |
| Diary    | -112   | Obv.' 5      |                           | Night of the 15th first part Venus [was ... above $\alpha$ Scorpïi ...]   |
| GYT      | 82     | Obv.' 9      | 217                       | Night of the 13th first part Venus was 3 cubits below $\beta$ Geminorum   |
| Diary    | -94    | 'Flake' 11'  |                           | [13th...] first part Venus was 3 cubits below $\beta$ Geminorum   |
| GYT      | 5      | Rev.' 15     | 35                        | The 23rd, Mercury's last appearance in the west in Aquarius   |
| Diary    | -276   | 'Rev.' 1'    |                           | The 26th, Mercury's [last appearance] in Aquar[ius ...]   |

## Appendix B

| Text No. |        |              | Observations<br>year (SE) |  |
|----------|--------|--------------|---------------------------|--|
| GYT      | 5      | Rev.' 15     | 35                        | Around the 11th, first appearance in the east in Aquarius  |
| Diary    | -276   | 'Rev.' 4'    |                           | The 12th, Mercury's first appearance in the east in Aquarius   |
| GYT      | 7      | Obv. 16      | 45                        | The 14th, last appearance in the west in Sagittarius   |
| Diary    | -266 B | 'Obv.' 16'   |                           | The 1st, Mercury's last appearance in the west in Sagittarius  |
| GYT      | 15     | Obv. 20      | 60                        | The 11th, Mercury's first appearance in the west ... omitted   |
| Diary    | -251   | Obv. 3       |                           | The 11th, Mercury's first appearance in the west, omitted  |
| GYT      | 15     | Obv. 20      | 60                        | The 26th, Mercury's [...]  |
| Diary    | -251   | Obv. 6       |                           | Around the 26th, Mercury's last appearance in the west, omitted  |
| GYT      | 28     | 'Obv.' 2'    | 85                        | The 13th, Mercury's [...] in the east  |
| Diary    | -226 A | 'Obv.' 19'   |                           | The 13th, Mercury's first appearance in the east ... omitted   |
| GYT      | 34     | 'Obv.' 6'    | 93                        | Around the 25th, Mercury's last appearance in the west ... omitted   |
| Diary    | -218   | 'Obv.' 2'    |                           | The 25th, Mercury's last appearance in the west ... omitted  |
| GYT      | 50     | 'Obv.' 8'    | 122                       | The 8th, Mercury's last appearance in the west in Gemini; I did not watch  |
| Diary    | -189 A | 'Obv.' 11'   |                           | Around the 8th, Mercury's last appearance in the west in Gemini; I did not watch   |
| GYT      | 53     | 'Obv.' 21'   | 125                       | Around the 1st, Mercury's last appearance in the west in the end of Pisces; I did not watch  |
| Diary    | -186 A | 'Rev.' 5'    |                           | [... the 1st, Mercu]ry's last appearance in the west in the end of Pisces; I did not watch   |
| GYT      | 53     | Obv. 20'-21' | 125                       | The 14th, Mercury's [first appearance] in the west in Pisces, [it stood] 2 ½ cubits behind Venus to the east; [it was bright and high, sunset to setting of Mercury: 16°; (ideal) first on the 12th  |
| Diary    | -186 C | Obv. 15      |                           | The 14th, Mercury's first appearance in the west in [Virgo], it stood 2 ½ cubits behind Venus to the west(sic); it was bright and high, sunset to setting of Mercury: 16°; (ideal) first on the 12th |

## Appendix B

| Text No. |                     |            | Observations<br>year (SE) |   |
|----------|---------------------|------------|---------------------------|---|
| GYT      | 62                  | Obv.' 14   | 140                       | [The 1]6th, Mercury's last appearance in the east in Aries, I did not watch   |
| Diary    | -171 A              | 'Rev.' 6'  |                           | The 16th, Mercury's last appearance in the east in Aries  |
| GYT      | 62                  | Obv.' 17   | 140                       | The 17th, Mercury's last appearance in the east in the beginning of Leo   |
| Diary    | -171 B              | Obv.' 3    |                           | The 18th, Mercury's last appearance in the east in the beginning of Leo   |
| GYT      | 69                  | Obv. 21    | 148                       | Night of the 2nd first part Mercury was 1 ½ cubits below β Tauri  |
| Diary    | -163 A              | Obv.' 2    |                           | The 1st, first part Mercury was 1 ½ [cubits] below β Tauri  |
| GYT      | 69                  | Obv. 22    | 148                       | Night of the 9th first part Mercury was 1 cubit 4 fingers above η Geminorum   |
| Diary    | -163 A              | Obv.' 11   |                           | Night of the 9th first part Me[rcury was ... above η Geminorum]   |
| GYT      | 69                  | Obv. 22-23 | 148                       | Night of the 11th first part [Mercury was] 1 cubit 4 fingers above μ Geminorum  |
| Diary    | -163 A              | Obv.' 14   |                           | Night of the 11th first part Mercury was 1 2/3 cubits above μ Geminorum   |
| GYT      | 69                  | Obv. 23    | 148                       | Night of the 15th first part Mercury was 4 ½ cubits [above γ] Geminorum   |
| Diary    | -163 A              | Obv.' 18   |                           | Night of the 15th first part [Mercury was] 4 ½ cubits [above γ Geminorum]   |
| GYT      | 69                  | Obv. 31-32 | 148                       | The 17th, Mercury's last appearance [in the ea]st [in] Pisces: from the 14th in the end of Aquarius, when I watched I did not see it              |
| Diary    | -163 B              | 'Rev. 10'  |                           | Around the 14th, Mercury's [last appearance in the east in Aquarius ...]  |
| GYT      | 69                  | Obv. 28-29 | 148                       | [Mercury's last appearance in the west] in Aquarius: from the 20th when I watched I did not see it  |
| Diary    | -163 C <sub>2</sub> | 'Obv. 15'  |                           | Around the 20th, Mercury's last appearance in the west in Aquarius  |
| GYT      | 69                  | Obv. 29-30 | 148                       | The 10th, Mercury's first appearance in the east in Capricorn, 3 cubits behind β Capricorni, 1 ½ <sup>2</sup> cubits ... (ideal) first appearance |
| Diary    | -163 C <sub>2</sub> | Rev.' 4    |                           | on the 8th<br>The 10th, Mercury's [first appearance] in the east in Capricorn, 3 cubits behind [β Capricorni...]                                  |

## Appendix B

| Text No. |        |              | Observations<br>year (SE) |  |
|----------|--------|--------------|---------------------------|--|
| GYT      | 73     | Obv. 32'-33' | 155                       | [Night of the 1]9th first part Mercury was 1 ½ cubits above ζ Tauri  |
| Diary    | -156 A | 'Obv.' 8'    |                           | Night of the 19th first part Mercury was 1 ½ cubits above ζ Tauri  |
| GYT      | 73     | Obv. 33'     | 155                       | Night of the 10[+xth first part Mercury was] 1 <sup>2</sup> cubit 4 fingers [above η Geminorum]  |
| Diary    | -156 A | 'Obv.' 12'   |                           | [...] first part Mercury was 1 cubit 4 fingers above η Geminorum   |
| GYT      | 73     | Rev. 7-8     | 156                       | The 24th, Mercury's [first appearance] in the west in Leo, 4 fingers below [Venus, being 2 fingers back to the west;] it was small, sunset to setting of Mercury: 15°  |
| Diary    | -155A  | Obv. 14-15   |                           | The 24th, Mercury's [first appearance] in the west in Leo, 4 fingers below Venus, 2 fingers [...] it was small, sunset to setting of Mercury: 15°  |
| GYT      | 82     | Obv.' 17-18  | 179                       | The 8th, Mercury's first appearance in the west in Gemini, it was bright and high, sunset to setting of Mercury: 15°30', (ideal) first on the 6th.   |
| Diary    | -132 A | 'Obv.' 13'   |                           | [8-9th ...] Mercury's first appearance in the west in Gemini, it was bright, sunset to setting of Mercury: 15°30' [(ideal) first] on the 5th [...]   |
| GYT      | 82     | Obv.' 20     | 179                       | The 2nd, Mercury's first appearance in the west ... omitted  |
| Diary    | -132 B | Obv. 31      |                           | The 2nd, Mercury's first appearance in the west ... omitted  |
| GYT      | 82     | Obv.' 20-21  | 179                       | The 14th <sup>2</sup> , [Mercury's last appearance] in the west ... omitted  |
| Diary    | -132 B | Rev. 2       |                           | The 14th, Mer[cury's last appearance in the west ...] omitted  |
| GYT      | 82     | Obv. 21-22   | 179                       | [The xth], Mercury's first appearance in the east in the beginning of Scorpius, 3 cubits behind β Librae, 2 ½ cubits low to the south; it was bright, rising of Mercury to sunrise: 16°; (ideal) first on [the xth] of Month VII |
| Diary    | -132 B | Rev. 17      |                           | Around the 29th, Mercury's [first appearance in] the east in Scorpius  |
| GYT      | 86     | Obv. 21      | 190                       | The 19th, Mercury's first appearance in the west in Cancer; sunset to setting of Mercury: 15°; (ideal) first on the 17th   |
| Diary    | -121   | 'Obv. 4'     |                           | Around the 17th, Mercury's [first appearance] in the west in Cancer  |

## Appendix B



| Text No. |                     |              | Observations<br>year (SE) |   |
|----------|---------------------|--------------|---------------------------|---|
| GYT      | 12                  | 'Obv. 4'     | 38                        | Until the 4th Saturn became stationary to the west, [it became stationary] in Aqua[r rius]  |
| Diary    | -273 B              | Obv.' 1-2    |                           | The 4th, [Saturn became stationary in Aquarius, I did not watch]  |
| GYT      | 12                  | 'Obv. 5'     | 38                        | [...the 2]1st, Saturn's first appearance in Pisces; it was bright and high; rising of Saturn to sunrise: 18°, (ideal) first on the 19                         |
| Diary    | -273 B              | 'Rev. 23'    |                           | The 2[1st, Saturn's] first appearance in Pisces; it was bright and high; rising of Saturn to sunrise: 17°, (ideal) first on the 19                            |
| GYT      | 18                  | 'Obv. 5'     | 48                        | Around the 18th, Saturn's acronychal rising   |
| Diary    | -263                | 'Obv.' 14'   |                           | The 18th, Saturn's acrony[chal rising]  |
| GYT      | 50                  | 'Obv. 17'    | 109                       | [... Sat]urn's first appearance in Leo, 2 2/3 cubits behind α Leonis to the east ... (ideal) first on the 11th  |
| Diary    | -202 A              | 'Rev.' 8'    |                           | Around the 11th, Saturn's first appearance in Leo   |
| GYT      | 53                  | 'Obv.' 22'   | 112                       | Until the 28th <sup>2</sup> , when Saturn became stationary to the west, [it became stationary] 2 ½ cubits behind β Vir[ginis]                                |
| Diary    | -199 A              | 'Obv.' 3'    |                           | Around the 1st, when Saturn [became stationary to the west, it became stationary nn cubits] [behind β Virginis]   |
| GYT      | 61                  | 'Obv. 28'    | 126                       | The 30th, Saturn's [first appearance] in the beginning of Pisces, ½ <sup>2</sup> cubit in front <sup>2</sup> of...  |
| Diary    | -185 B              | 'Obv.' 8'-9' |                           | Around the 30th, Saturn's first appearance ½ cubit below Mars, it stood 2 cubits [in front of Jupiter to] the west, 3 ½ cubits behind Mercury to the east ... |
|          |                     | 'Obv.' 6'-7' |                           | alt: The 22nd, Saturn's first appearance in the beginning of Pisces [2 cubits in] front of Jupiter to the west ... (ideal) first on 21st                      |
| GYT      | 74                  | Obv.' 30     | 143                       | Around <sup>2</sup> the 27th, Saturn's [first appearance in ...]  |
| Diary    | -168 B              | 'Obv.' 9'    |                           | The 27th, Saturn's [first appearance] in Libra  |
| GYT      | 77                  | Obv. 23      | 148                       | [... Saturn's last appearance] in Scorpio: from the 11th, when I watched I did not see it   |
| Diary    | -163 C <sub>1</sub> | 'Obv.' 8'    |                           | Around the 11th, Saturn's last appearance in the end of Scorpio   |
| GYT      | 86                  | Obv. 28      | 177                       | The 4th, Saturn's last appearance in Scorpio, from the 2nd when I watched I did not see it  |
| Diary    | -134 B              | Obv.' 19     |                           | The 4th, setting of Saturn in Scorpio, from the 1st when I watched I did not see it   |

## Appendix B

| Text No. |        |            | Observations<br>year (SE) |  |
|----------|--------|------------|---------------------------|--|
| GYT      | 5      | Rev.' 25   | 34                        | [...] Mars was 2 cubits below $\alpha$ Scorpii   |
| Diary    | -277 C | Obv. 3     |                           | Night of the 11th first part Mars was 2 ½ cubits above $\alpha$ Scorpii  |
| GYT      | 12     | Rev.' 6    | 50                        | Night of the 28th last part Mars was [...] above [ $\rho$ Leonis]  |
| Diary    | -261 C | Obv.' 8    |                           | [Night of the 28th last part Mars] was 10 fingers [above] $\rho$ Leonis  |
| GYT      | 18     | Rev.' 1    | 28                        | The 23rd, Mars' first appearance in Libra; rising of Mars to sunrise: 18°; (ideal) first on the 19 <sup>2</sup>                            |
| Diary    | -283 A | Obv. 5     |                           | The 30th, Mars' first appearance in Libra; rising of Mars to sunrise: 19°; (ideal) first on the 21   |
| GYT      | 20     | Obv. 34-35 | 71                        | [... Mars ...] 4 fingers [... $\alpha$ Librae]   |
| Diary    | -240   | 'Obv. 12'  |                           | Night of the 11th last part Mars was 4 fingers above $\alpha$ Librae   |
| GYT      | 27     | Obv. 33    | 50                        | Until the 23rd, when Mars [became stationary] to the west [...]  |
| Diary    | -261 B | 'Rev.' 5'  |                           | [... Around the 23rd, when Mars became stationary to the west, it became stationary ... behind $\rho$ Le]onis, 1 cubit behind Sa[turn ...] |
| GYT      | 27     | Rev. 1-2   | 82                        | [... Mars, while] moving [back to the west,] was 4 cubits below $\theta$ Leonis  |
| Diary    | -229 B | 'Rev.' 6'  |                           | [Night of the 18th first part Mars was] 4 cubits [... $\theta$ ] Leonis  |
| GYT      | 90     | 'Rev.' 8'  | 199                       | [Night] of the 25th last part Mars was [...] above $\delta$ Cap[ricorni]   |
| Diary    | -112   | 'Rev. 11'  |                           | [Ni]ght of the 25th last part Mars was [...] above $\delta$ Capri[corni]   |

***Appendix C: a comparison of Greek-letter phenomena dates from the ACT ephemerides and the non-mathematical predictive texts***

| Planet  | Scheme  |                       |      |       |                  |                  |             |             |                 |        |                 |     |                          |
|---------|---------|-----------------------|------|-------|------------------|------------------|-------------|-------------|-----------------|--------|-----------------|-----|--------------------------|
| Mercury | A2      | no comparisons remain |      |       |                  |                  |             |             |                 |        |                 |     |                          |
|         |         |                       |      |       |                  |                  |             |             |                 |        |                 |     |                          |
| Mercury | A1      | Zodiacal sign         |      |       |                  |                  |             |             |                 |        |                 |     |                          |
| ACT     |         | Duplicates            | Year | Month | Day              | Observation      | ACT         | Prediction  | Predictive text |        | Month           | Day | Dates agree <sup>2</sup> |
| 300     | Obv. 36 | 301 Obv. 2            | 129  | III   | 22               | first appearance | Gemini      | Gemini      | LBAT 1123       | Obv. 6 | III             | 24  | No                       |
| 300     | Obv. 36 |                       | 129  | IV    | 11               | last appearance  | [...]       | Gemini      | LBAT 1123       | Obv. 7 | IV              | 9   | No                       |
| 300     | Rev. 4  |                       | 133  | V     | 9                | last appearance  | [...]       | Leo         | MLC 1885        | Obv. 9 | V               | 10  | No                       |
| 300     | Rev. 5  |                       | 133  | VIII  | [3]              | first appearance | Scorpio     | Libra       | MLC 1885        | Rev. 5 | VII             | 29  | No                       |
| 300     | Rev. 5  |                       | 133  | IX    | 15               | last appearance  | Sagittarius | Sagittarius | MLC 1885        | Rev. 9 | IX              | 13  | No                       |
| 301     | Obv. 1  |                       | 133  | III   | 23               | last appearance  | Cancer      | Cancer      | MLC 1885        | Obv. 2 | III             | 23  | Yes                      |
| 301     | Obv. 1  |                       | 133  | V     | 6                | last appearance  | Leo         | Leo         | MLC 1885        | Obv. 9 | V               | 10  | No                       |
| 301     | Obv. 2  |                       | 133  | VI    | 29               | first appearance | Libra       | omitted     | MLC 1885        | Rev. 1 | VII             | 2   | No                       |
| 301     | Obv. 2  |                       | 133  | VII   | 14               | last appearance  | Scorpio     | omitted     | MLC 1885        | Rev. 3 | VII             | 14  | Yes                      |
| 301     | Obv. 2  |                       | 133  | VII   | 29               | first appearance | Scorpio     | Libra       | MLC 1885        | Rev. 5 | VII             | 29  | Yes                      |
| 301     | Obv. 8  | 147                   | VI   | 14    | first appearance | Libra            | Libra       | MLC 2915    | Obv. 11         | VII    | 22              | No  |                          |
| 301     | Obv. 8  | 147                   | VIII | 20    | last appearance  | Scorpio          | Sagittarius | MLC 2915    | Obv. 15         | IX     | 10              | No  |                          |
| 301     | Obv. 9  | 147                   | X    | 9     | first appearance | Capricorn        | Aquarius    | MLC 2915    | Rev. 1          | X      | 8               | No  |                          |
| 301     | Obv. 9  | 147                   | XI   | 1     | last appearance  | Aquarius         | Aquarius    | MLC 2915    | Rev. 3          | XI     | 1               | Yes |                          |
| 301     | Obv. 9  | 147                   | XI   | 9     | first appearance | Aquarius         | Aquarius    | MLC 2915    | Rev. 3-4        | XI     | 15              | No  |                          |
| 301     | Obv. 9  | 147                   | XII  | 13    | last appearance  | Pisces           | Pisces      | MLC 2915    | Rev. 6          | XII    | 19              | No  |                          |
| 301     | Obv. 16 | 150                   | I    | 17    | last appearance  | Taurus           | Taurus      | LBAT *1030  | Obv. 3-4        | I      | 19 <sup>2</sup> | No  |                          |
| 301     | Obv. 16 | 150                   | II   | 10    | first appearance | Taurus           | Taurus      | LBAT *1030  | Obv. 8          | II     | 19              | No  |                          |
| 301     | Obv. 17 | 150                   | V    | 10    | last appearance  | Virgo            | Virgo       | LBAT *1030  | Obv. 19-20      | V      | 14              | No  |                          |
| 301     | Obv. 17 | 150                   | V    | 25    | first appearance | Leo              | Virgo       | LBAT *1030  | Obv. 24         | VI     | 8               | No  |                          |
| 301     | Obv. 17 | 150                   | VI   | 22    | last appearance  | Virgo            | Virgo       | LBAT *1030  | Rev. 1          | VII    | 5 or 4          | No  |                          |
| 302     | Obv. 17 | 172                   | V    | 1     | first appearance | Cancer           | Cancer      | LBAT 1038   | Obv. 20         | V      | 2               | No  |                          |

Appendix C

|     |         |     |      |    |                  |             |             |             |           |                 |    |     |
|-----|---------|-----|------|----|------------------|-------------|-------------|-------------|-----------|-----------------|----|-----|
| 302 | Obv. 18 | 172 | VIII | 21 | first appearance | Scorpio     | Sagittarius | LBAT 1038   | Rev. 9    | X               | 1  | No  |
| 302 | Obv. 19 | 172 | XI   | 7  | first appearance | Aquarius    | [...]       | LBAT 1038   | Rev. 13   | XI              | 5  | No  |
| 302 | Rev. -2 | 178 | II   | 8  | last appearance  | Aries       | omitted     | LBAT 1134   | Obv. 2    | II              | 21 | No  |
| 302 | Rev. -1 | 178 | V    | 16 | first appearance | Leo         | Leo         | LBAT 1134   | Obv. 9    | V               | 20 | No  |
| 302 | Rev. -1 | 178 | VI   | 12 | last appearance  | Leo         | Leo         | LBAT 1134   | Obv. 12   | VI              | 12 | Yes |
| 302 | Rev. 0  | 178 | VIII | 4  | first appearance | Scorpio     | Scorpio     | LBAT 1134   | Rev. 1    | VIII            | 6  | No  |
| 302 | Rev. 1  | 178 | XI   | 24 | first appearance | Pisces      | Pisces      | LBAT 1134   | Rev. 10   | XI              | 21 | No  |
| 302 | Rev. 4  | 179 | X    | 18 | first appearance | Aquarius    | Aquarius    | LBAT 1136   | Rev. 6    | X               | 16 | No  |
| 302 | Rev. 4  | 179 | XI   | 10 | last appearance  | Pisces      | Pisces      | LBAT 1135   | Rev. 2    | XI              | 11 | No  |
| 302 | Rev. 4  | 179 | XII  | 30 | last appearance  | Pisces      | [...]       | LBAT 1135   | Rev. 6    | XII             | 29 | No  |
| 302 | Rev. 14 | 183 | I    | 23 | first appearance | Taurus      | omitted     | LBAT 1137-8 | Obv. 7    | III             | 3  | No  |
| 302 | Rev. 14 | 183 | III  | 7  | last appearance  | Taurus      | omitted     | LBAT 1137-8 | Obv. 8    | III             | 13 | No  |
| 302 | Rev. 15 | 183 | V    | 14 | last appearance  | Virgo       | Gemini      | LBAT 1137-8 | Obv. 13   | V               | 20 | No  |
| 302 | Rev. 16 | 183 | VIII | 25 | first appearance | Sagittarius | Sagittarius | LBAT 1137-8 | Rev. 4    | VIII            | 29 | No  |
| 302 | Rev. 16 | 183 | IX   | 11 | last appearance  | Sagittarius | [...]       | LBAT 1137-8 | Rev. 5    | IX              | 14 | No  |
| 302 | Rev. 16 | 183 | IX   | 27 | first appearance | Sagittarius | [...]       | LBAT 1137-8 | Rev. 6    | IX              | 27 | Yes |
| 302 | Rev. 16 | 183 | XI   | 4  | last appearance  | Capricorn   | Capricorn   | LBAT 1137-8 | Rev. 9    | XI              | 10 | No  |
| 302 | Rev. 17 | 183 | XII  | 14 | first appearance | Pisces      | Pisces      | LBAT 1137-8 | Rev. 11   | XII             | 10 | No  |
| 302 | Rev. 19 | 184 | X    | 8  | last appearance  | Capricorn   | Capricorn   | LBAT 1047   | Obv. 15   | X <sup>?</sup>  | 5  | No  |
| 302 | Rev. 20 | 184 | XI   | 10 | first appearance | Pisces      | Pisces      | LBAT 1047   | Obv. 18   | XI <sup>?</sup> | 7  | No  |
| 302 | Rev. 20 | 184 | XII  | 2  | last appearance  | Aries       | Aries       | LBAT 1048   | Line 25   | XII             | 3  | No  |
| 302 | Rev. 30 | 188 | I    | 7  | first appearance | Taurus      | Taurus      | LBAT 1051   | Obv. 1    | I               | 7  | Yes |
| 302 | Rev. 30 | 188 | II   | 16 | last appearance  | Gemini      | Gemini      | LBAT 1051   | Obv. 8    | II              | 13 | No  |
| 302 | Rev. 30 | 188 | III  | 16 | first appearance | Gemini      | Gemini      | LBAT 1051   | Obv. 15   | III             | 17 | No  |
| 302 | Rev. 30 | 188 | IV   | 5  | last appearance  | Gemini      | [...]       | LBAT 1051   | Obv. 19   | IV              | 5  | Yes |
| 302 | Rev. 31 | 188 | VI   | 30 | first appearance | Virgo       | Virgo       | LBAT 1052   | Obv. 9-10 | VI              | 29 | No  |
| 302 | Rev. 31 | 188 | VIII | 2  | last appearance  | Libra       | Libra       | LBAT 1052   | Rev. 5    | VII             | 30 | No  |
| 302 | Rev. 32 | 188 | X    | 6  | last appearance  | Capricorn   | Aquarius    | LBAT 1051   | Rev. 10   | X               | 8  | No  |
| 302 | Rev. 32 | 188 | X    | 19 | first appearance | Capricorn   | Capricorn   | LBAT 1051   | Rev. 11   | X               | 20 | No  |
| 302 | Rev. 32 | 188 | XII  | 4  | last appearance  | Aquarius    | Aquarius    | LBAT 1051   | Rev. 19   | XI              | 28 | No  |
| 302 | Rev. 33 | 189 | II   | 9  | last appearance  | Taurus      | Taurus      | LBAT **1055 | Obv. 8    | II              | 4  | No  |

## Appendix C

|     |         |  |     |                 |    |                  |        |        |              |            |                 |    |     |
|-----|---------|--|-----|-----------------|----|------------------|--------|--------|--------------|------------|-----------------|----|-----|
| 302 | Rev. 33 |  | 189 | III             | 12 | first appearance | Taurus | Taurus | LBAT' **1055 | Obv. 14-15 | III             | 12 | Yes |
| 302 | Rev. 33 |  | 189 | III             | 29 | last appearance  | Gemini | Gemini | LBAT' **1055 | Obv. 17    | III             | 28 | No  |
| 302 | Rev. 34 |  | 189 | IV              | 24 | first appearance | Leo    | Leo    | LBAT' **1055 | Obv. 23    | IV              | 26 | No  |
| 302 | Rev. 34 |  | 189 | VI              | 24 | first appearance | Virgo  | Virgo  | LBAT' **1055 | Obv. 37-38 | VI              | 25 | No  |
| 302 | Rev. 34 |  | 189 | VI <sub>2</sub> | 23 | last appearance  | Libra  | Libra  | LBAT' **1055 | Rev. 43    | VI <sub>2</sub> | 23 | Yes |

|        |        |  |      |       |     |                  |               |            |            |         |                 |     |              |
|--------|--------|--|------|-------|-----|------------------|---------------|------------|------------|---------|-----------------|-----|--------------|
| Venus  | A0     |  |      |       |     |                  | Zodiacal sign |            |            |         |                 |     |              |
| ACT no |        |  | Year | Month | Day | Observation      | ACT           | Prediction | NSA/Alm no |         | Month           | Day | Dates agree? |
| 400    | Obv. 1 |  | 111  | V     | 27  | first appearance | Libra         | Libra      | LBAT 1020  | Obv. 13 | VI <sup>2</sup> | 12  | No           |
| 400    | Rev. 0 |  | 129  | I     | 12  | first appearance | Taurus        | Taurus     | LBAT 1123  | Obv. 2  | I               | 21  | No           |

|        |        |  |      |       |     |                  |               |            |            |        |       |     |              |
|--------|--------|--|------|-------|-----|------------------|---------------|------------|------------|--------|-------|-----|--------------|
| Venus  | A1     |  |      |       |     |                  | Zodiacal sign |            |            |        |       |     |              |
| ACT no |        |  | Year | Month | Day | Observation      | ACT           | Prediction | NSA/Alm no |        | Month | Day | Dates agree? |
| 410    | Line 1 |  | 236  | II    | 6   | first appearance | Gemini        | Gemini     | LBAT 1174  | Obv. 3 | II    | 6   | Yes          |
| 410    | Line 1 |  | 236  | X     | 18  | last appearance  | Aquarius      | Aquarius   | LBAT 1174  | Rev. 7 | XI    | 6   | No           |
| 411    | Line 2 |  | 248  | I     | 24  | first appearance | Aries         | [...]      | LBAT 1183  | Obv. 1 | I     | 16  | No           |

|        |         |              |      |       |     |                  |               |             |              |         |       |     |              |
|--------|---------|--------------|------|-------|-----|------------------|---------------|-------------|--------------|---------|-------|-----|--------------|
| Venus  | A2      |              |      |       |     |                  | Zodiacal sign |             |              |         |       |     |              |
| ACT no |         |              | Year | Month | Day | Observation      | ACT           | Prediction  | NSA/Alm no   |         | Month | Day | Dates agree? |
| 420    | Obv. 6  | 421a Obv. 3  | 188  | XI    | 27  | last appearance  | Pisces        | Pisces      | LBAT 1051    | Rev. 20 | XI    | 29  | No           |
| 420    | Obv. 6  | 421a Obv. 3  | 188  | XII   | 1   | first appearance | Pisces        | Pisces      | LBAT 1051    | Rev. 21 | XII   | 1   | Yes          |
| 420    | Obv. 12 | 421a Obv. 9  | 198  | VI    | 6   | last appearance  | Libra         | [...]       | LBAT 1148-9  | Obv. 5  | VI    | 2   | No           |
| 420    | Obv. 12 | 421a Obv. 11 | 201  | IX    | 5   | last appearance  | Sagittarius   | Sagittarius | LBAT' **1059 | Line 48 | IX    | 3   | No           |
| 420    | Obv. 12 | 421a Obv. 11 | 201  | IX    | 6   | first appearance | Sagittarius   | Sagittarius | LBAT' **1059 | Line 48 | IX    | 5   | No           |
| 420    | Obv. 12 | 421a Obv. 11 | 201  | IX    | 6   | first appearance | Sagittarius   | [...]       | LBAT 1151    | Rev. 3  | IX    | 6   | Yes          |
| 420    | Rev. 2  |              | 233  | VIII  | 20  | first appearance | Sagittarius   | Sagittarius | LBAT 1160    | Rev. 2  | VIII  | 20  | Yes          |
| 420    | Rev. 4  |              | 236  | XI    | 3   | last appearance  | Aquarius      | Aquarius    | LBAT 1169-74 | Rev. 4  | XI    | 6   | No           |
| 420    | Rev. 4  |              | 236  | XI    | 7   | first appearance | Aquarius      | Aquarius    | LBAT 1169-74 | Rev. 4  | XI    | 8   | No           |

## Appendix C

| Mars   | A       | Zodiacal sign |      |       |     |                   |          |            |             |         |       |     |                          |
|--------|---------|---------------|------|-------|-----|-------------------|----------|------------|-------------|---------|-------|-----|--------------------------|
| ACT no |         |               | Year | Month | Day | Observation       | ACT      | Prediction | NSA/Alm no  |         | Month | Day | Dates agree <sup>?</sup> |
| 500    | Obv. 18 |               | 127  | IX    | 26  | acronychal rising |          |            | BM 32888    | Rev. 4  | IX    | 20  | No                       |
| 500    | Obv. 19 |               | 129  | XI    | 20  | acronychal rising |          |            | LBAT 1123   | Rev. 1  | XI    | 14  | No                       |
| 501    | Obv. 29 | 501b Obv. 5   | 183  | II    | 26  | station           | Aquarius | Capricorn  | LBAT 1137-8 | Obv. 5  | II    | 20  | No                       |
| 501    | Rev. 2  |               | 189  | VII   | 17  | station           | Cancer   | Cancer     | LBAT **1055 | Rev. 45 | VII   | 11  | No                       |

| Jupiter | A       |             |      |                 |     |                   | Zodiacal sign |            |            |            |                 |          |              |
|---------|---------|-------------|------|-----------------|-----|-------------------|---------------|------------|------------|------------|-----------------|----------|--------------|
| ACT no  |         |             | Year | Month           | Day | Observation       | ACT           | Prediction | NSA/Alm no |            | Month           | Day      | Dates agree? |
| 600     | Obv. 4  |             | 116  | IV              | 22  | station           | Aries         | Aries      | 1021       | Obv. 3     | IV              | 26       | No           |
| 600     | Obv. 16 |             | 129  | VI              | 28  | station           | Gemini        | Gemini     | 1123       | Obv. 12    | VII             | 1        | No           |
| 600     | Obv. 20 |             | 133  | X               | 20  | [station]         | Libra         | Libra      | MLC 1885   | Rev. 13    | X               | 24       | No           |
| 600     | Rev. 6  |             | 156  | X               | 12  | station           | Virgo         | Virgo      | 1032       | Rev. 7     | X               | 10       | No           |
| 601     | Obv. 14 | 602 Obv. 18 | 150  | VII             | 10  | station           | Aquarius      | Aquarius   | 1030       | Rev. 1     | VII             | 14       | No           |
| 602     | Obv. 2  |             | 133  | V               | 19  | last appearance   | Virgo         | Virgo      | MLC 1885   | Obv. 10    | V               | 18       | No           |
| 602     | Obv. 15 |             | 147  | VII             | 30  | last appearance   | Scorpio       | Pisces?    | MLC 2915   | Obv. 12    | VII             | 24       | No           |
| 602     | Obv. 23 |             | 156  | V               | 11  | last appearance   | Leo           | Libra      | 1032       | Obv. 13    | V               | 9        | No           |
| 602     | Obv. 27 |             | 160  | IX              | 4   | last appearance   | Sagittarius   | Capricorn  | 1129       | Rev. 6     | [IX]            | 7        | No           |
| 602     | Rev. 1  | 605 Obv. 11 | 201  | II              | 9   | last appearance   | Gemini        | Gemini     | **1059     | Obv. 10    | II              | 13       | No           |
| 603     | Obv. 4  |             | 150  | V               | 9   | acronychal rising | Aquarius      | Aquarius   | 1030       | Obv. 20    | V               | 15 or 16 | No           |
| 603     | Obv. 4  |             | 150  | VII             | 8   | station           | Aquarius      | Aquarius   | 1030       | Rev. 1     | VII             | 14       | No           |
| 604     | Obv. 13 |             | 172  | III             | 10  | acronychal rising | Sagittarius   |            | 1028       | Obv. 13-14 | III             | 13       | No           |
| 604     | Obv. 29 |             | 189  | VIII            | 28  | acronychal rising | Cancer        |            | **1055     | Rev. 48    | VIII            | 26       | No           |
| 604a    | Line 4  |             | 189  | VI <sub>2</sub> | 29  | station           | Cancer        | Gemini     | **1055     | Rev. 44    | VI <sub>2</sub> | 26       | No           |
| 606     | Obv. 15 |             | 129  | I               | 24  | last appearance   | Taurus        | Taurus     | 1123       | Obv. 3     | I               | 24       | Yes          |
| 606     | Obv. 19 |             | 133  | V               | 20  | last appearance   | Virgo         | Virgo      | MLC 1885   | Obv. 10    | V               | 18       | No           |
| 606     | Obv. 32 |             | 147  | VIII            | 1   | last appearance   | Scorpio       | Pisces?    | MLC 2915   | Obv. 12    | VII             | 24       | No           |

## Appendix C

|     |        |     |     |    |                 |          |          |          |          |     |    |    |
|-----|--------|-----|-----|----|-----------------|----------|----------|----------|----------|-----|----|----|
| 605 | Obv. 0 | 189 | II  | 22 | last appearance | Gemini   | Gemini   | **1055   | Obv. 12  | II  | 25 | No |
| 605 | Obv. 1 | 189 | X   | 27 | station         | Gemini   | Gemini   | **1055   | Rev. 58  | X   | 24 | No |
| 605 | Obv. 1 | 190 | III | 8  | last appearance | Cancer   | Cancer   | 1144     | Obv. 4   | III | 10 | No |
| 605 | Obv. 8 | 197 | XI  | 15 | last appearance | Aquarius | Aquarius | BM 45716 | Rev. 9   | XI  | 19 | No |
| 605 | Rev. 2 | 209 | XI  | 3  | last appearance | Aquarius | Aquarius | 1153     | Rev. 3   | XI  | 9  | No |
| 607 | Obv. 1 | 209 | II  | 27 | station         | Aquarius | Aquarius | 1154-5   | Obv. 4-5 | II  | 26 | No |

| Jupiter | A'      | Zodiacal sign |                 |     |                   |             |             |            |            |                 |     |              |
|---------|---------|---------------|-----------------|-----|-------------------|-------------|-------------|------------|------------|-----------------|-----|--------------|
| ACT no  |         | Year          | Month           | Day | Observation       | ACT         | Prediction  | NSA/Alm no |            | Month           | Day | Dates agree? |
| 610     | Obv. 4  | 147           | VIII            | 1   | last appearance   | Scorpio     | Pisces?     | MLC 2915   | Obv. 12    | VII             | 24  | No           |
| 610     | Obv. 7  | 150           | VII             | 9   | station           | Aquarius    | Aquarius    | 1030       | Rev. 1     | VII             | 14  | No           |
| 610     | Obv. 12 | 156           | V               | 11  | last appearance   | Leo         | Leo         | 1032       | Obv. 13    | V               | 9   | No           |
| 610     | Rev. 14 | 184           | IX              | 10  | last appearance   | Capricorn   | Capricorn   | 1047       | Obv. 13    | VIII?           | 12  | No           |
| 610     | Rev. 17 | 188           | I               | 5   | last appearance   | Aries       | Taurus      | 1051       | Obv. 2     | I               | 10  | No           |
| 610     | Rev. 18 | 189           | II              | 22  | last appearance   | Gemini      | Gemini      | **1055     | Obv. 12    | II              | 25  | No           |
| 610     | Rev. 19 | 189           | X               | 25  | station           | Gemini      | Gemini      | **1055     | Rev. 58    | X               | 24  | No           |
| 610     | Rev. 23 | 194           | III             | 15  | station           | Libra       | Libra       | 1057       | Obv. 14    | III             | 19  | No           |
| 611     | Obv. 4  | 183           | IX              | 22  | first appearance  | Sagittarius | Sagittarius | 1137-8     | Rev. 6     | IX              | 22  | Yes          |
| 611     | Obv. 8  | 188           | VIII            | 12  | acronychal rising | Taurus      |             | 1052       | Rev. 7     | VIII            | 11  | No           |
| 611     | Obv. 9  | 189           | III             | 20  | first appearance  | Gemini      | Gemini      | **1055     | Obv. 15-16 | III             | 22  | No           |
| 611     | Obv. 9  | 189           | VI <sub>2</sub> | 26  | station           | Gemini      | Gemini      | **1055     | Rev. 44    | VI <sub>2</sub> | 26  | Yes          |
| 611     | Obv. 13 | 194           | I               | 18  | acronychal rising | Libra       |             | 1057       | Obv. 2     | I               | 16  | No           |
| 611     | Obv. 20 | 201           | III             | 7   | first appearance  | Gemini      | Gemini      | **1059     | Line 15    | III             | 12  | No           |
| 611     | Obv. 20 | 201           | VII             | 14  | station           | Cancer      | Cancer      | **1059     | Line 37    | VII             | 11  | No           |
| 611     | Obv. 20 | 201           | IX              | 15  | acronychal rising | Gemini      |             | **1059     | Line 49    | IX              | 11  | No           |
| 611     | Obv. 27 | 208           | X               | 15  | first appearance  | Capricorn   | Aquarius    | BM 32230   | Rev. 2     | X               | 19  | No           |
| 611     | Obv. 28 | 209           | XII             | 3   | first appearance  | Pisces      | Pisces      | 1153       | Rev. 9     | XII             | 10  | No           |
| 611     | Obv. 27 | 209           | II              | 23  | station           | Aquarius    | Aquarius    | 1154-5     | Obv. 4-5   | II              | 26  | No           |
| 611     | Rev. 13 | 233           | II              | 29  | station           | Aquarius    | Aquarius    | 1160       | Obv. 4     | III             | 2   | No           |
| 611     | Rev. 14 | 234           | IV              | 17  | station           | Aries       | Aries       | 1164-5     | Obv. 8     | IV              | 13  | No           |
| 611     | Rev. 16 | 236           | II              | 15  | first appearance  | Taurus      | Taurus      | 1174       | Obv. 4     | II              | 20  | No           |

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|      |         |     |      |    |                   |          |          |          |         |      |    |    |
|------|---------|-----|------|----|-------------------|----------|----------|----------|---------|------|----|----|
| 611  | Rev. 16 | 236 | VI   | 21 | station           | Gemini   | Gemini   | 1174     | Obv. 12 | VI   | 22 | No |
| 611  | Rev. 16 | 236 | VIII | 22 | acronychal rising | Gemini   |          | 1174     | Rev. 2  | VIII | 24 | No |
| 611  | Rev. 24 | 245 | III  | 17 | station           | Pisces   | Pisces   | 1179-80  | Obv. 5  | III  | 20 | No |
| 611  | Rev. 24 | 245 | V    | 18 | acronychal rising | Aquarius |          | 1179-80  | Obv. 11 | V    | 21 | No |
| 611  | Rev. 26 | 247 | I    | 15 | first appearance  | Aries    | Aries    | 1182     | Obv. 2  | I    | 22 | No |
| 612  | Obv. 0  | 188 | I    | 5  | last appearance   | Taurus   | Taurus   | 1051     | Obv. 2  | I    | 10 | No |
| 612  | Obv. 6  | 194 | III  | 16 | station           | Libra    | Libra    | 1057     | Obv. 14 | III  | 19 | No |
| 612  | Obv. 9  | 197 | XI   | 16 | last appearance   | Aquarius | Aquarius | BM 45716 | Rev. 9  | XI   | 19 | No |
| 612  | Obv. 12 | 201 | II   | 9  | last appearance   | Gemini   | Gemini   | **1059   | Line 10 | II   | 13 | No |
| 612  | Obv. 13 | 201 | XI   | 13 | station           | Gemini   | Gemini   | **1059   | Line 60 | XI   | 11 | No |
| 612  | Rev. 2  | 209 | XI   | 14 | last appearance   | Aquarius | Aquarius | 1153     | Rev. 7  | XI   | 9  | No |
| 613a | Obv. 7  | 209 | XI   | 5  | last appearance   | Aquarius | Aquarius | 1153     | Rev. 7  | XI   | 9  | No |
| 613a | Obv. 29 | 233 | XI   | 11 | last appearance   | Pisces   | Pisces   | 1160     | Rev. 8  | XI   | 15 | No |
| 613a | Obv. 31 | 236 | I    | 17 | last appearance   | Taurus   | Taurus   | 1174     | Obv. 1  | I    | 19 | No |
| 613a | Rev. 3  | 245 | XI   | 29 | last appearance   | Pisces   | Pisces   | 1179-80  | Rev. 22 | XI   | 25 | No |
| 613a | Rev. 5  | 248 | II   | 5  | last appearance   | Taurus   | Taurus   | 1183     | Obv. 3  | II   | 6  | No |

| Jupiter | B       | Zodiacal sign |       |     |                   |                 |            |            |            |         |                 |                          |    |
|---------|---------|---------------|-------|-----|-------------------|-----------------|------------|------------|------------|---------|-----------------|--------------------------|----|
| ACT no  |         | Year          | Month | Day | Observation       | ACT             | Prediction | NSA/Alm no |            | Month   | Day             | Dates agree <sup>2</sup> |    |
| 620     | Obv. 21 | 150           | V     | 13  | acronychal rising | Aquarius        | Aquarius   | 1030       | Obv. 20    | V       | 15 or 16        | No                       |    |
| 620     | Obv. 27 | 156           | XII   | 12  | acronychal rising | Virgo           | Virgo      | 1032       | Rev. 13    | XII     | 11 <sup>2</sup> | No                       |    |
| 620     | Rev. 5  | 172           | III   | 12  | acronychal rising | Sagittarius     |            | 1038       | Obv. 13-14 | III     | 13              | No                       |    |
| 620     | Rev. 21 | 189           | VIII  | 28  | acronychal rising | Gemini          |            | **1055     | Rev. 48    | VIII    | 26              | No                       |    |
| 620     | Rev. 25 | 194           | I     | 17  | acronychal rising | Libra           |            | 1057       | Obv. 2     | I       | 16              | No                       |    |
| 621a    | Obv. 2  | 188           | I     | 5   | last appearance   | Aries           | Taurus     | 1051       | Obv. 2     | I       | 10              | No                       |    |
| 621a    | Obv. 3  | 189           | II    | 22  | last appearance   | Gemini          | Gemini     | **1055     | Obv. 12    | II      | 25              | No                       |    |
| 621a    | Obv. 4  | 190           | III   | 8   | last appearance   | Cancer          | Cancer     | 1144       | Obv. 4     | III     | 10 <sup>2</sup> | No                       |    |
| 621a    | Obv. 11 | 622 Obv. 7    | 197   | XI  | 14                | last appearance | Aquarius   | Aquarius   | BM 45716   | Rev. 9  | XI              | 19                       | No |
| 621a    | Obv. 14 | 622 Obv. 10   | 201   | II  | 10                | last appearance | Gemini     | Gemini     | **1059     | Line 10 | II              | 13                       | No |
| 622     | Obv. 4  | 194           | III   | 16  | station           | Libra           | Libra      | 1057       | Obv. 14    | III     | 19              | No                       |    |
| 622     | Obv. 11 | 201           | XI    | 15  | station           | Gemini          | Gemini     | **1059     | Line 60    | XI      | 11              | No                       |    |

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|     |         |     |    |    |                 |        |        |         |         |    |    |    |
|-----|---------|-----|----|----|-----------------|--------|--------|---------|---------|----|----|----|
| 623 | Rev. 2  | 233 | XI | 9  | last appearance | Pisces | Pisces | 1160    | Rev. 8  | XI | 15 | No |
| 623 | Rev. 4  | 236 | I  | 17 | last appearance | Taurus | Taurus | 1174    | Obv. 1  | I  | 19 | No |
| 623 | Rev. 13 | 245 | XI | 27 | last appearance | Pisces | Pisces | 1179-80 | Rev. 22 | XI | 25 | No |
| 623 | Rev. 15 | 248 | II | 5  | last appearance | Taurus | Taurus | 1183    | Obv. 3  | II | 6  | No |

| Jupiter | B'      | Zodiacal sign |       |     |                  |       |            |            |         |       |     |              |
|---------|---------|---------------|-------|-----|------------------|-------|------------|------------|---------|-------|-----|--------------|
| ACT no  |         | Year          | Month | Day | Observation      | ACT   | Prediction | NSA/Alm no |         | Month | Day | Dates agree? |
| 640     | Obv. 14 | 156           | VII   | 2   | first appearance | Virgo | Virgo      | 1032       | Obv. 17 | VI    | 10  | No           |

| Saturn | Zodiacal sign |      |       |     |                   |     |            |            |         |       |     |              |
|--------|---------------|------|-------|-----|-------------------|-----|------------|------------|---------|-------|-----|--------------|
| ACT no |               | Year | Month | Day | Observation       | ACT | Prediction | NSA/Alm no |         | Month | Day | Dates agree? |
| 702    | Rev. 3        | 178  | III   | 3   | acronychal rising |     |            | 1134       | Obv. 3  | III   | 1   | No           |
| 702    | Rev. 4        | 179  | II    | 26  | acronychal rising |     |            | 1135       | Obv. 4  | II    | 23  | No           |
| 704    | Obv. 4        | 158  | VI    | 19  | acronychal rising |     |            | 1034-5     | Rev. 17 | VI    | 18  | No           |

***Appendix D: a summary of the records from the Diaries and the Almanacs concerning the dates of planets' entries into zodiacal signs***

**Appendix D1: Sign entry data from the Astronomical Diaries**

| Date (Seleucid Era) |                  |    | Planet  | Zodiacal Sign | Tropical Longitude (°) |
|---------------------|------------------|----|---------|---------------|------------------------|
| 99                  | X                | 9  | Venus   | Sagittarius   | 236.93                 |
| 107                 | I                | 10 | Venus   | Gemini        | 54.17                  |
| 108                 | VIII             | 23 | Venus   | Aquarius      | 292.93                 |
| 118                 | VII              | 5  | Mars    | Virgo         | 144.25                 |
| 118                 | X                | 15 | Mars    | Scorpio       | 205.37                 |
| 118                 | XII              | 9  | Venus   | Aquarius      | 294.88                 |
| 118                 | XII              | 15 | Mercury | Aries         | 357.73                 |
| 122                 | II               | 12 | Venus   | Taurus        | 22.69                  |
| 122                 | II               | 6  | Mars    | Cancer        | 85.47                  |
| 125                 | II               | 5  | Venus   | Pisces        | 321.09                 |
| 129                 | II               | 18 | Mars    | Leo           | 142.48                 |
| 129                 | VIII             | 12 | Venus   | Capricorn     | 261.78                 |
| 129                 | II               | 24 | Mercury | Aquarius      | 292.67                 |
| 129                 | VIII             | 10 | Saturn  | Pisces        | 353.49                 |
| 130                 | IV               | 3  | Venus   | Cancer        | 85.41                  |
| 130                 | IV               | 15 | Jupiter | Cancer        | 83.1                   |
| 133                 | XII              | 26 | Venus   | Taurus        | 25.9                   |
| 133                 | V                | 11 | Mars    | Leo           | 115.22                 |
| 133                 | XII              | 4  | Mercury | Pisces        | 316.73                 |
| 138                 | X                | 15 | Venus   | Pisces        | 324.06                 |
| 138                 | X                | 20 | Jupiter | Pisces        | 318                    |
| 155                 | VIII             | 29 | Venus   | Scorpio       | 203.21                 |
| 157                 | IV               | 15 | Venus   | Cancer        | 87.7                   |
| 158                 | V                | 6  | Venus   | Libra         | 176.15                 |
| 162                 | VII              | 29 | Mars    | Capricorn     | 266.49                 |
| 167                 | VIII             | 7  | Mars    | Libra         | 175.15                 |
| 167                 | VIII             | 22 | Mercury | Scorpio       | 210.37                 |
| 170                 | III              | 20 | Mars    | Aries         | 351.64                 |
| 171                 | I                | 19 | Mars    | Cancer        | 86.04                  |
| 171                 | I                | 21 | Venus   | Cancer        | 83.42                  |
| 171                 | VII              | 3  | Venus   | Virgo         | 145.61                 |
| 171                 | VII              | 21 | Jupiter | Sagittarius   | 234.15                 |
| 171                 | X                | 28 | Mars    | Capricorn     | 272.7                  |
| 171                 | II               | 7  | Venus   | Aquarius      | 292.63                 |
| 174                 | II               | 30 | Mars    | Taurus        | 25.37                  |
| 174                 | IV               | 16 | Mars    | Gemini        | 56.19                  |
| 174                 | X                | 5  | Venus   | Sagittarius   | 236.38                 |
| 175                 | XII <sub>2</sub> | 16 | Mercury | Taurus        | 28.97                  |
| 175                 | VI               | 30 | Saturn  | Scorpio       | 205.09                 |
| 177                 | VI               | 9  | Mercury | Virgo         | 147.17                 |
| 177                 | VII              | 4  | Venus   | Sagittarius   | 234.27                 |
| 177                 | XII              | 7  | Venus   | Aquarius      | 294.5                  |
| 179                 | VII              | 1  | Venus   | Virgo         | 145.83                 |
| 179                 | VII              | 28 | Venus   | Libra         | 175.02                 |
| 179                 | VII              | 21 | Mars    | Capricorn     | 264.66                 |
| 182                 | VI               | 14 | Mars    | Virgo         | 145.97                 |
| 186                 | V                | 12 | Mercury | Leo           | 114.53                 |
| 186                 | I                | 2  | Venus   | Pisces        | 322.3                  |
| 186                 | I                | 29 | Venus   | Aries         | 352.21                 |

| Date (Seleucid Era) |                  |    | Planet  | Zodiacal Sign | Tropical Longitude (°) |
|---------------------|------------------|----|---------|---------------|------------------------|
| 187                 | II               | 13 | Mercury | Cancer        | 84.49                  |
| 187                 | III              | 15 | Venus   | Cancer        | 117.08                 |
| 187                 | IX               | 17 | Venus   | Sagittarius   | 237.14                 |
| 187                 | X                | 11 | Venus   | Capricorn     | 265.51                 |
| 188                 | III              | 8  | Venus   | Cancer        | 83.57                  |
| 188                 | V                | 23 | Venus   | Libra         | 174.44                 |
| 189                 | II               | 7  | Mars    | Aries         | 349.81                 |
| 189                 | VI <sub>2</sub>  | 8  | Mars    | Cancer        | 85.15                  |
| 192                 | II               | 22 | Mars    | Virgo         | 145.91                 |
| 193                 | VII              | 3  | Venus   | Sagittarius   | 236.22                 |
| 194                 | II               | 26 | Venus   | Aries         | 355.31                 |
| 194                 | XII              | 10 | Mars    | Aries         | 351.45                 |
| 199                 | VII              | 26 | Mars    | Libra         | 175.76                 |
| 200                 | I                | 14 | Mercury | Gemini        | 57.46                  |
| 200                 | II               | 10 | Mars    | Pisces        | 321.07                 |
| 203                 | I                | 16 | Venus   | Cancer        | 83.93                  |
| 203                 | IV               | 12 | Mercury | Virgo         | 147.21                 |
| 204                 | VIII             | 3  | Mercury | Sagittarius   | 238.19                 |
| 204                 | IX               | 13 | Mercury | Scorpio       | 234.74                 |
| 204                 | XII              | 2  | Venus   | Aquarius      | 322.23                 |
| 204                 | XII              | 23 | Venus   | Pisces        | 320.97                 |
| 204                 | XII              | 28 | Mars    | Cancer        | 84.44                  |
| 206                 | I                | 2  | Venus   | Gemini        | 55.7                   |
| 206                 | I                | 3  | Mars    | Aries         | 353.5                  |
| 206                 | I                | 27 | Venus   | Cancer        | 85.17                  |
| 206                 | II               | 13 | Mercury | Cancer        | 86.72                  |
| 206                 | II               | 24 | Venus   | Leo           | 114.81                 |
| 208                 | II               | 6  | Mercury | Gemini        | 57.03                  |
| 215                 | I                | 7  | Venus   | Aries         | 355.39                 |
| 215                 | IX               | 14 | Venus   | Aquarius      | 294.82                 |
| 216                 | I                | 6  | Mercury | Taurus        | 20.64                  |
| 217                 | I                | 18 | Venus   | Gemini        | 55.2                   |
| 218                 | V                | 7  | Venus   | Leo           | 118.55                 |
| 221                 | II               | 7  | Jupiter | Pisces        | 324.6                  |
| 221                 | II               | 13 | Venus   | Pisces        | 322.91                 |
| 224                 | VI               | 10 | Venus   | Leo           | 116.21                 |
| 224                 | XII <sub>2</sub> | 21 | Venus   | Taurus        | 25.25                  |
| 225                 | II               | 11 | Venus   | Cancer        | 86.22                  |
| 225                 | IV               | 27 | Mercury | Leo           | 118.83                 |
| 226                 | X                | 23 | Venus   | Pisces        | 324.85                 |
| 226                 | X                | 23 | Mars    | Pisces        | 325.02                 |
| 228                 | III              | 23 | Venus   | Leo           | 113.93                 |
| 229                 | X                | 19 | Mercury | Capricorn     | 264.2                  |
| 229                 | X                | 17 | Venus   | Aquarius      | 296.13                 |
| 229                 | XII <sub>2</sub> | 1  | Venus   | Taurus        | 25.06                  |
| 234                 | II               | 15 | Mercury | Aquarius      | 292.82                 |
| 234                 | II               | 16 | Venus   | Taurus        | 26.15                  |
| 234                 | III              | 12 | Venus   | Gemini        | 57.41                  |
| 234                 | IV               | 7  | Venus   | Cancer        | 86.63                  |
| 234                 | IV               | 16 | Mars    | Taurus        | 25.68                  |
| 234                 | V                | 2  | Venus   | Leo           | 117.42                 |
| 234                 | VII              | 13 | Mercury | Libra         | 178.67                 |
| 238                 | III              | 23 | Mars    | Gemini        | 56.28                  |

| Date (Seleucid Era) |      |    | Planet | Zodiacal Sign | Tropical Longitude (°) |
|---------------------|------|----|--------|---------------|------------------------|
| 239                 | VIII | 18 | Venus  | Sagittarius   | 235.32                 |

## Appendix D2: Sign entry data from the Almanacs

| Date (Seleucid Era) |                  |    | Planet  | Zodiacal Sign | Tropical Longitude (°) |
|---------------------|------------------|----|---------|---------------|------------------------|
| 128                 | VI               | 6  | Jupiter | Aries         | 25.21                  |
| 128                 | VI               | 23 | Mars    | Scorpio       | 209.17                 |
| 128                 | VII              | 24 | Venus   | Libra         | 174.94                 |
| 129                 | II               | 2  | Mercury | Gemini        | 55.65                  |
| 129                 | II               | 10 | Mars    | Taurus        | 20.5                   |
| 129                 | II               | 14 | Saturn  | Aries         | 355.9                  |
| 129                 | III              | 6  | Venus   | Cancer        | 85.78                  |
| 129                 | IV               | 7  | Mars    | Gemini        | 58.36                  |
| 129                 | IV               | 27 | Venus   | Virgo         | 146.33                 |
| 129                 | IV               | 28 | Jupiter | Gemini        | 54.97                  |
| 129                 | V                | 12 | Mercury | Virgo         | 147.54                 |
| 129                 | V                | 28 | Mars    | Cancer        | 90.84                  |
| 129                 | XI               | 14 | Mars    | Leo           | 143.84                 |
| 129                 | XII              | 15 | Venus   | Aquarius      | 291.7                  |
| 129                 | XII <sub>2</sub> | 16 | Mercury | Taurus        | 25.2                   |
| 129                 | XII <sub>2</sub> | 25 | Venus   | Pisces        | 331.82                 |
| 157                 | III              | 10 | Mars    | Taurus        | 27.34                  |
| 157                 | III              | 18 | Mercury | Leo           | 112.49                 |
| 157                 | IV               | 23 | Mars    | Gemini        | 54.78                  |
| 158                 | III              | 23 | Mercury | Leo           | 113.29                 |
| 158                 | IX               | 8  | Venus   | Scorpio       | 205.64                 |
| 158                 | XI               | 4  | Venus   | Capricorn     | 265.46                 |
| 160                 | VI               | 10 | Mars    | Scorpio       | 207.64                 |
| 162                 | IV               | 20 | Venus   | Leo           | 116.29                 |
| 162                 | IX               | 9  | Mars    | Aquarius      | 296.3                  |
| 162                 | IX               | 19 | Venus   | Aquarius      | 298.72                 |
| 162                 | V                | 7  | Mars    | Scorpio       | 205.99                 |
| 162                 | V                | 22 | Mercury | Virgo         | 178.13                 |
| 162                 | VI               | 20 | Mars    | Sagittarius   | 236.49                 |
| 178                 | III              | 13 | Mercury | Cancer        | 82.97                  |
| 178                 | III              | 25 | Venus   | Gemini        | 55.37                  |
| 178                 | IV               | 4  | Mercury | Leo           | 115.25                 |
| 178                 | V                | 3  | Mars    | Cancer        | 83.26                  |
| 178                 | V                | 15 | Venus   | Leo           | 111.46                 |
| 178                 | VI               | 9  | Venus   | Virgo         | 143.75                 |
| 178                 | VI               | 24 | Mars    | Leo           | 116.24                 |
| 178                 | XI               | 29 | Venus   | Aries         | 354.12                 |
| 179                 | II               | 17 | Mercury | Cancer        | 85.3                   |
| 179                 | III              | 2  | Venus   | Leo           | 116.02                 |
| 179                 | IX               | 20 | Venus   | Sagittarius   | 237.78                 |
| 179                 | XI               | 8  | Mercury | Pisces        | 328.42                 |
| 179                 | XI               | 25 | Mars    | Aries         | 357.76                 |
| 179                 | XI               | 30 | Venus   | Pisces        | 322.87                 |
| 183                 | IV               | 8  | Mercury | Leo           | 114.67                 |
| 183                 | IX               | 10 | Mercury | Capricorn     | 263.86                 |
| 183                 | IX               | 21 | Venus   | Aquarius      | 293.76                 |
| 183                 | IX               | 23 | Saturn  | Aquarius      | 295.3                  |

| Date (Seleucid Era) |      |    | Planet  | Zodiacal Sign | Tropical Longitude (°) |
|---------------------|------|----|---------|---------------|------------------------|
| 183                 | VI   | 14 | Venus   | Libra         | 176.11                 |
| 183                 | VIII | 25 | Venus   | Capricorn     | 264.32                 |
| 183                 | VIII | 27 | Mars    | Pisces        | 323.91                 |
| 183                 | X    | 15 | Mars    | Aries         | 353.32                 |
| 183                 | X    | 15 | Venus   | Pisces        | 322.65                 |
| 183                 | XI   | 13 | Venus   | Aries         | 353.81                 |
| 183                 | XII  | 8  | Mars    | Taurus        | 26.45                  |
| 183                 | XII  | 14 | Mercury | Aries         | 352.48                 |
| 183                 | XII  | 15 | Jupiter | Capricorn     | 264.44                 |
| 183                 | XII  | 16 | Venus   | Taurus        | 26.85                  |
| 185                 | XI   | 5  | Mercury | Pisces        | 325.4                  |
| 185                 | XII  | 25 | Mars    | Gemini        | 57.19                  |
| 189                 | III  | 11 | Venus   | Taurus        | 25.6                   |
| 189                 | III  | 24 | Mars    | Taurus        | 26.47                  |
| 189                 | IV   | 10 | Venus   | Gemini        | 55.97                  |
| 189                 | V    | 11 | Mars    | Gemini        | 55.26                  |
| 189                 | VI   | 2  | Venus   | Leo           | 116.65                 |
| 190                 | II   | 2  | Venus   | Cancer        | 85.26                  |
| 190                 | II   | 2  | Mars    | Leo           | 115.456                |
| 190                 | II   | 28 | Venus   | Leo           | 115.08                 |
| 190                 | XI   | 20 | Saturn  | Taurus        | 25.19                  |
| 190                 | XI   | 29 | Mercury | Aries         | 354.57                 |
| 198                 | IV   | 30 | Venus   | Libra         | 175.67                 |
| 198                 | IX   | 1  | Mars    | Pisces        | 325.67                 |
| 198                 | IX   | 28 | Venus   | Sagittarius   | 235.16                 |
| 198                 | VIII | 30 | Venus   | Scorpio       | 204.5                  |
| 200                 | III  | 21 | Mercury | Cancer        | 84.64                  |
| 200                 | X    | 26 | Mars    | Taurus        | 24.82                  |
| 201                 | I    | 18 | Mercury | Gemini        | 55.55                  |
| 201                 | III  | 29 | Mercury | Cancer        | 89.52                  |
| 201                 | IX   | 12 | Jupiter | Gemini        | 84.72                  |
| 201                 | IX   | 25 | Mercury | Aquarius      | 291.32                 |
| 201                 | V    | 4  | Venus   | Libra         | 175.91                 |
| 201                 | V    | 22 | Jupiter | Cancer        | 85.19                  |
| 201                 | VI   | 1  | Venus   | Scorpio       | 206.3                  |
| 201                 | VII  | 1  | Venus   | Sagittarius   | 236.12                 |
| 201                 | VIII | 17 | Mars    | Scorpio       | 208.84                 |
| 201                 | XI   | 29 | Saturn  | Virgo         | 176.06                 |
| 201                 | XII  | 1  | Venus   | Aquarius      | 292.29                 |
| 201                 | XII  | 17 | [Mars]  | Aquarius      | 294.73                 |
| 209                 | I    | 19 | Venus   | Gemini        | 54.54                  |
| 209                 | II   | 15 | Venus   | Cancer        | 84.95                  |
| 209                 | II   | 30 | Mercury | Gemini        | 59.3                   |
| 209                 | III  | 10 | Venus   | Leo           | 115.1                  |
| 209                 | IV   | 4  | Mars    | Libra         | 175.29                 |
| 209                 | IX   | 18 | Mars    | Aquarius      | 294.05                 |
| 209                 | X    | 9  | Mercury | Capricorn     | 263.96                 |
| 209                 | X    | 25 | Saturn  | Capricorn     | 264.92                 |
| 209                 | X    | 28 | Mars    | Pisces        | 325.27                 |
| 209                 | XI   | 1  | Mercury | Aquarius      | 293.26                 |
| 209                 | XI   | 28 | Venus   | Aquarius      | 291.45                 |
| 209                 | XII  | 5  | Mercury | Aries         | 354.73                 |
| 209                 | XII  | 29 | Venus   | Pisces        | 324.72                 |

| Date (Seleucid Era) |      |    | Planet  | Zodiacal Sign | Tropical Longitude (°) |
|---------------------|------|----|---------|---------------|------------------------|
| 220                 | XI   | 11 | Venus   | Aquarius      | 326.24                 |
| 220                 | XII  | 5  | Mercury | Pisces        | 320.84                 |
| 220                 | XII  | 19 | Mars    | Pisces        | 324.69                 |
| 220                 | XII  | 20 | Venus   | Pisces        | 318.33                 |
| 226                 | XI   | 19 | Venus   | Aries         | 355.23                 |
| 226                 | XII  | 2  | Mars    | Aries         | 353.58                 |
| 226                 | XII  | 15 | Mercury | Pisces        | 320.88                 |
| 233                 | III  | 17 | Mars    | Leo           | 116.91                 |
| 233                 | IV   | 4  | Venus   | Virgo         | 150.01                 |
| 233                 | IX   | 9  | Venus   | Scorpio       | 236.07                 |
| 233                 | VI   | 26 | Venus   | [Sagittarius] | 235.9                  |
| 233                 | VII  | 28 | Mercury | Scorpio       | 210.9                  |
| 233                 | VIII | 4  | Mars    | Scorpio       | 206.6                  |
| 233                 | X    | 6  | Jupiter | Pisces        | 325.32                 |
| 233                 | X    | 25 | Venus   | Capricorn     | 263.23                 |
| 233                 | X    | 28 | Mars    | Capricorn     | 267.28                 |
| 233                 | XII  | 1  | Mercury | Pisces        | 322.08                 |
| 233                 | XII  | 28 | Venus   | Pisces        | 330.75                 |
| 234                 | I    | 4  | Saturn  | Libra         | 205.5                  |
| 234                 | I    | 14 | Mars    | [Pisces]      | 323.93                 |
| 234                 | I    | 17 | Mars    | Pisces        | 326.17                 |
| 234                 | I    | 20 | Venus   | Aries         | 356.47                 |
| 234                 | I    | 22 | Mercury | Gemini        | 55.95                  |
| 234                 | II   | 16 | Venus   | Taurus        | 26.15                  |
| 234                 | II   | 28 | Mars    | Aries         | 355.16                 |
| 234                 | III  | 12 | Venus   | Gemini        | 57.41                  |
| 234                 | IV   | 17 | Mars    | Taurus        | 26.27                  |
| 234                 | V    | 2  | Venus   | Leo           | 117.42                 |
| 234                 | V    | 30 | Saturn  | Scorpio       | 204.61                 |
| 234                 | VI   | 28 | Jupiter | Pisces        | 353.81                 |
| 234                 | XII  | 13 | Venus   | Taurus        | 25.61                  |
| 236                 | I    | 26 | Mars    | Aries         | 356.38                 |
| 236                 | II   | 26 | Venus   | Cancer        | 83.93                  |
| 236                 | II   | 29 | Jupiter | Gemini        | 54.65                  |
| 236                 | III  | 9  | Mars    | Taurus        | 26.34                  |
| 236                 | III  | 22 | Mercury | Leo           | 116.1                  |
| 236                 | III  | 21 | Venus   | Leo           | 114.6                  |
| 236                 | IV   | 15 | Venus   | Virgo         | 144                    |
| 236                 | IV   | 25 | Mars    | Gemini        | 56.6                   |
| 236                 | IX   | 4  | Saturn  | Sagittarius   | 235.49                 |
| 236                 | V    | 11 | Venus   | Libra         | 175.7                  |
| 236                 | VI   | 3  | Mercury | Virgo         | 148.21                 |
| 236                 | VI   | 8  | Venus   | Scorpio       | 207.13                 |
| 236                 | VI   | 29 | Mars    | Cancer        | 86.37                  |
| 236                 | VII  | 2  | Venus   | Sagittarius   | 235.73                 |
| 236                 | VII  | 28 | Venus   | Capricorn     | 265.86                 |
| 236                 | VIII | 25 | Mars    | Gemini        | 86.87                  |
| 236                 | VIII | 26 | Venus   | Aquarius      | 294.98                 |
| 236                 | X    | 5  | Venus   | Pisces        | 324.3                  |
| 236                 | X    | 8  | Mercury | Capricorn     | 269.17                 |
| 236                 | X    | 24 | Venus   | Aquarius      | 325.01                 |
| 236                 | XI   | 28 | Mercury | Aries         | 355.3                  |
| 236                 | XII  | 14 | Mars    | Cancer        | 84.85                  |

| Date (Seleucid Era) |                  |    | Planet             | Zodiacal Sign         | Tropical Longitude (°) |
|---------------------|------------------|----|--------------------|-----------------------|------------------------|
| 237                 | XI               | 8  | Venus              | Pisces                | 324.25                 |
| 241                 | IV               | 17 | Mercury            | Virgo                 | 144.25                 |
| 241                 | IV               | 25 | Venus              | Libra                 | 175.78                 |
| 244                 | II               | 22 | Mercury            | Cancer                | 85.95                  |
| 244                 | II               | 25 | Venus              | Cancer                | 85.83                  |
| 244                 | XII              | 29 | Venus              | Pisces                | 325.03                 |
| 247                 | I                | 22 | Venus              | Taurus                | 23.96                  |
| 247                 | I                | 25 | Jupiter            | Taurus                | 23.78                  |
| 247                 | IV               | 6  | Mercury            | Cancer                | 104.4                  |
| 247                 | V                | 27 | Venus              | Libra                 | 175.21                 |
| 247                 | VIII             | 10 | Venus              | Capricorn             | 300.57                 |
| 248                 | I                | 29 | Mercury            | Cancer <sup>1</sup>   | 50.5                   |
| 248                 | II               | 29 | Venus              | Taurus                | 22.83                  |
| 248                 | VI               | 5  | Venus              | Leo                   | 117.04                 |
| 248                 | X                | 7  | Venus              | Capricorn             | 267.15                 |
| 254                 | XII <sub>2</sub> | 18 | Mercury            | Taurus                | 27.49                  |
| 282                 | IX               | 1  | Mars               | Sagittarius           | 237.79                 |
| 282                 | X                | 6  | Mercury            | Capricorn             | 268.44                 |
| 300                 | II               | 4  | Mars               | Aries                 | 356.72                 |
| 300                 | II               | 15 | Venus              | Gemini                | 54.97                  |
| 300                 | III              | 11 | Venus <sup>2</sup> | Cancer                | 88.05                  |
| 300                 | III              | 26 | Jupiter            | Libra                 | 176.95                 |
| 300                 | IV               | 6  | Venus              | Leo                   | 116.16                 |
| 300                 | VII              | 20 | Mercury            | Libra                 | 177.32                 |
| 301                 | II               | 27 | Mercury            | Gemini                | 58.87                  |
| 301                 | III              | 14 | Venus              | Gemini                | 57.89                  |
| 301                 | III              | 16 | Mars               | Virgo                 | 146.77                 |
| 301                 | IV               | 8  | Venus              | Cancer                | 86.62                  |
| 301                 | V                | 4  | Venus              | Leo                   | 117.12                 |
| 301                 | V                | 5  | Mars               | Libra                 | 177.2                  |
| 301                 | V                | 28 | Venus              | Virgo                 | 146.87                 |
| 303                 | IV               | 16 | Mercury            | Leo                   | 127.36                 |
| 303                 | VI               | 14 | Venus              | Libra                 | 176.11                 |
| 305                 | II               | 21 | Venus              | Cancer                | 86.42                  |
| 305                 | II               | 26 | Mercury            | Cancer                | 86.13                  |
| 305                 | IV               | 14 | Venus              | Virgo                 | 147.45                 |
| 305                 | IX               | 16 | Mars               | Aquarius              | 295.74                 |
| 305                 | V                | 16 | Mars               | Scorpio               | 207.74                 |
| 305                 | VI               | 12 | Venus              | Scorpio               | 207.29                 |
| 305                 | VIII             | 8  | Mars               | Aquarius <sup>2</sup> | 266.2                  |
| 305                 | VIII             | 16 | Mercury            | Scorpio               | 206.76                 |
| 305                 | X                | 10 | Venus              | Sagittarius           | 233.06                 |
| 305                 | X                | 26 | Mars               | Pisces                | 325.9                  |
| 305                 | XII              | 7  | Mars               | Aries                 | 355.94                 |
| 305                 | XII <sub>2</sub> | 14 | Mars               | Taurus                | 22.6                   |
| 342                 | I                | 1  | Venus              | Gemini                | 58.08                  |
| 342                 | XI               | 14 | Venus              | Aquarius              | 296.37                 |
| 342                 | XII              | 12 | Venus              | Pisces                | 329.48                 |
| 355                 | I                | 14 | Jupiter            | Gemini                | 56.96                  |
| 355                 | III              | 5  | Venus              | Taurus                | 55.52                  |
| 355                 | III              | 14 | Mercury            | Leo                   | 117.54                 |
| 355                 | IV               | 23 | Venus              | Cancer                | 85.18                  |
| 355                 | IX               | 5  | Venus              | Sagittarius           | 237.87                 |

| Date (Seleucid Era) |      |    | Planet  | Zodiacal Sign            | Tropical Longitude (°) |
|---------------------|------|----|---------|--------------------------|------------------------|
| 355                 | IX   | 8  | Mercury | Sagittarius              | 240.88                 |
| 355                 | IX   | 19 | Mars    | Scorpio                  | 206.52                 |
| 355                 | IX   | 29 | Mercury | Capricorn                | 269.06                 |
| 355                 | IX   | 29 | Venus   | Capricorn                | 267.86                 |
| 355                 | VI   | 14 | Mars    | Virgo                    | 147.72                 |
| 355                 | VI   | 21 | Venus   | Virgo                    | 147.97                 |
| 355                 | VII  | 16 | Venus   | Libra                    | 178.24                 |
| 355                 | VIII | 11 | Venus   | Scorpio                  | 207.93                 |
| 372                 | I    | 2  | Venus   | Taurus                   | 25.43                  |
| 372                 | I    | 4  | Jupiter | Taurus <sup>3</sup>      | 206.62                 |
| 372                 | I    | 15 | Mars    | Gemini                   | 63.78                  |
| 372                 | II   | 22 | Venus   | Cancer                   | 86.67                  |
| 372                 | III  | 18 | Venus   | Leo                      | 119.48                 |
| 372                 | IV   | 13 | Venus   | Virgo                    | 147.22                 |
| 372                 | V    | 9  | Venus   | Libra                    | 177.01                 |
| 372                 | V    | 20 | Mercury | Libra                    | 174.37                 |
| 372                 | VI   | 5  | Venus   | Scorpio                  | 207.34                 |
| 372                 | VII  | 3  | Venus   | Sagittarius              | 237.54                 |
| 372                 | VII  | 8  | Mercury | Libra                    | 177.37                 |
| 372                 | VII  | 28 | Mars    | Libra                    | 178.65                 |
| 372                 | VIII | 3  | Venus   | Capricorn                | 267.35                 |
| 372                 | X    | 12 | Jupiter | Sagittarius <sup>4</sup> | 209.97                 |
| 372                 | XI   | 12 | Mercury | Aquarius                 | 295.97                 |
| 372                 | XII  | 2  | Venus   | Aquarius                 | 293.76                 |
| 385                 | I    | 6  | Venus   | Gemini                   | 57.75                  |
| 385                 | I    | 14 | Mercury | Gemini                   | 58.66                  |
| 385                 | II   | 2  | Venus   | Cancer                   | 88.75                  |
| 385                 | II   | 28 | Venus   | Leo                      | 119.01                 |
| 385                 | IV   | 27 | Venus   | Libra                    | 180.35                 |
| 385                 | V    | 12 | Mars    | Leo                      | 118.61                 |

<sup>1</sup> Error for Gemini

<sup>2</sup> Error for Capricorn

<sup>3</sup> Error for Scorpio

<sup>4</sup> Error for Scorpio



***Appendix E: a summary of records from the non-mathematical astronomical texts which refer to a planet's position within a zodiacal sign***

**Appendix E1: Beginning and end data from the Astronomical Diaries**

| Date (Regnal year or Seleucid Era) |                  |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|------------------------------------|------------------|-----|---------|---------------|------------------------|--------------------------|
| Darius II 5                        | I                | ~12 | Saturn  | Pisces        | Unclassified           | 355.02                   |
| Darius II 5                        | III              | 9   | Jupiter | Gemini        | Unclassified           | 82.33                    |
| Darius II 5                        | IV               | ~21 | Mercury | Leo           | Unclassified           | 128.06                   |
| Darius II 5                        | XII              | 29  | Mercury | Aries         | Unclassified           | 14.17                    |
| Darius II 5                        | XII <sub>2</sub> | ~1  | Saturn  | Pisces        | End                    | 4.27                     |
| Darius II 5                        | XII <sub>2</sub> | 21  | Venus   | Aries         | Unclassified           | 24.59                    |
| Arta II 29                         | XI               | 11  | Mars    | Capricorn     | Unclassified           | 293.69                   |
| Arta II 29                         | XII <sub>2</sub> | 7   | Venus   | Aries         | Beginning              | 357.34                   |
| Alex III 13                        | II               | 28  | Jupiter | Gemini        | Beginning              | 59.57                    |
| Alex III 13                        | III              | 3   | Mercury | Cancer        | Unclassified           | 88.4                     |
| Alex III 13                        | III              | 18  | Saturn  | Gemini        | Unclassified           | 73.86                    |
| Alex III 13                        | IV               | 15  | Mercury | Leo           | Unclassified           | 141.26                   |
| Alex III 13                        | V                | 18  | Venus   | Virgo         | Unclassified           | 181.1                    |
| 2                                  | V                | 24  | Jupiter | Virgo         | Beginning              | 158.14                   |
| 2                                  | VIII             | 21  | Mercury | Sagittarius   | Unclassified           | 244.02                   |
| 3                                  | I                | 8   | Saturn  | Sagittarius   | Unclassified           | 264.68                   |
| 3                                  | I                | 19  | Mercury | Taurus        | Unclassified           | 55.44                    |
| 3                                  | V                | 22  | Venus   | Virgo         | End                    | 175.22                   |
| 3                                  | VI               | 3   | Mercury | Libra         | Unclassified           | 190.06                   |
| 3                                  | VI               | 12  | Venus   | Virgo         | Unclassified           | 164.97                   |
| 18                                 | II               | 25  | Mars    | Taurus        | Beginning              | 30.51                    |
| 25                                 | VII              | ~7  | Saturn  | Libra         | Beginning              | 184.74                   |
| 30                                 | X                | 3   | Mercury | Capricorn     | Unclassified           | 294.7                    |
| 30                                 | X                | 5   | Mars    | Sagittarius   | End                    | 268.58                   |
| 51                                 | VI               | ~22 | Mercury | Libra         | Beginning              | 184.48                   |
| 55                                 | III              | 10  | Jupiter | Aquarius      | Unclassified           | 324.54                   |
| 55                                 | XI               | 1   | Mercury | Aquarius      | Unclassified           | 317.21                   |
| 55                                 | XI               | 15  | Saturn  | Libra         | Unclassified           | 198.23                   |
| 55                                 | XI               | 16  | Mercury | Aquarius      | Unclassified           | 304.68                   |
| 55                                 | XI               | 19  | Jupiter | Pisces        | Beginning              | 334.68                   |
| 56                                 | I                | 27  | Mercury | Taurus        | Unclassified           | 46.96                    |
| 56                                 | II               | 23  | Mars    | Gemini        | Unclassified           | 72                       |
| 56                                 | VI <sub>2</sub>  | ~18 | Mercury | Libra         | Beginning              | 181.53                   |
| 57                                 | IX               | ~20 | Mercury | Capricorn     | Unclassified           | 283.63                   |
| 57                                 | IX               | ~29 | Mercury | Sagittarius   | End                    | 273.03                   |
| 57                                 | X                | 18  | Venus   | Aquarius      | Unclassified           | 304.29                   |
| 57                                 | X                | 19  | Venus   | Aquarius      | Unclassified           | 303.45                   |
| 57                                 | XI               | 13  | Mercury | Aquarius      | Unclassified           | 309.71                   |
| 58                                 | VII              | 1   | Jupiter | Gemini        | Unclassified           | 71.9                     |
| 58                                 | VII              | 3   | Mercury | Virgo         | Unclassified           | 178.45                   |
| 58                                 | VII              | ~10 | Venus   | Libra         | Unclassified           | 187.52                   |
| 58                                 | VII              | ~18 | Saturn  | Scorpio       | Unclassified           | 221.09                   |
| 58                                 | VIII             | 23  | Saturn  | Scorpio       | Unclassified           | 225.04                   |
| 58                                 | XII <sub>2</sub> | ~9  | Mercury | Aries         | End                    | 20.93                    |
| 60                                 | VII              | 27  | Mars    | Libra         | Unclassified           | 205.99                   |
| 60                                 | VIII             | 6   | Saturn  | Sagittarius   | Beginning              | 243.7                    |
| 60                                 | VIII             | 13  | Mercury | Scorpio       | Unclassified           | 223.25                   |

Appendix E

| Date (Regnal year or Seleucid Era) |      |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|------------------------------------|------|-----|---------|---------------|------------------------|--------------------------|
| 60                                 | VIII | 17  | Jupiter | Leo           | Unclassified           | 135.46                   |
| 60                                 | XII  | 20  | Mercury | Pisces        | Unclassified           | 334.24                   |
| 60                                 | XII  | 21  | Jupiter | Leo           | Unclassified           | 124.35                   |
| 60                                 | XII  | 29  | Venus   | Aries         | Unclassified           | 15.46                    |
| 62                                 | IX   | ~20 | Mercury | Capricorn     | Unclassified           | 295.97                   |
| 62                                 | IX   | 27  | Saturn  | Capricorn     | Beginning              | 270.31                   |
| 62                                 | X    | ~11 | Mercury | Aquarius      | Unclassified           | 309.02                   |
| 62                                 | XII  | ~4  | Mercury | Pisces        | Unclassified           | 333.43                   |
| 65                                 | I    | 17  | Venus   | Taurus        | Unclassified           | 48.98                    |
| 65                                 | I    | ~18 | Mars    | Aries         | Unclassified           | 16.49                    |
| 65                                 | II   | 11  | Saturn  | Aquarius      | Beginning              | 300.13                   |
| 65                                 | VI   | 12  | Mercury | Virgo         | Unclassified           | 168.99                   |
| 70                                 | II   | ~16 | Jupiter | Taurus        | End                    | 58.94                    |
| 70                                 | II   | ~28 | Mercury | Gemini        | Unclassified           | 64.31                    |
| 79                                 | VII  | ~14 | Jupiter | Aquarius      | End                    | 324.98                   |
| 79                                 | VIII | 9   | Mercury | Sagittarius   | Unclassified           | 249.59                   |
| 79                                 | VIII | 14  | Mercury | Sagittarius   | Unclassified           | 247.63                   |
| 79                                 | VIII | 28  | Mercury | Scorpio       | Unclassified           | 233.4                    |
| 79                                 | X    | 8   | Mercury | Capricorn     | Unclassified           | 277.44                   |
| 79                                 | XI   | ~27 | Jupiter | Pisces        | Unclassified           | 345.61                   |
| 79                                 | XII  | 29  | Jupiter | Pisces        | Unclassified           | 353.26                   |
| 81                                 | I    | 13  | Venus   | Taurus        | Unclassified           | 48.87                    |
| 81                                 | I    | ~18 | Jupiter | Taurus        | Beginning              | 29.37                    |
| 81                                 | I    | 24  | Mercury | Gemini        | Beginning              | 64.79                    |
| 86                                 | III  | 26  | Mercury | Leo           | Unclassified           | 135.18                   |
| 86                                 | IV   | 14  | Mars    | Cancer        | Unclassified           | 112.2                    |
| 86                                 | IV   | 21  | Mercury | Leo           | Beginning              | 131.56                   |
| 90                                 | IX   | 4   | Mercury | Capricorn     | Beginning              | 271.86                   |
| 102                                | I    | 7   | Saturn  | Aries         | End                    | 26.98                    |
| 102                                | II   | 22  | Saturn  | Taurus        | Beginning              | 32.79                    |
| 102                                | III  | 4   | Mercury | Gemini        | Unclassified           | 81.08                    |
| 102                                | IV   | 9   | Mercury | Gemini        | Unclassified           | 81.86                    |
| 102                                | IV   | 23  | Mercury | Cancer        | Unclassified           | 106.69                   |
| 102                                | VI   | 5   | Mercury | Virgo         | Unclassified           | 176.73                   |
| 114                                | VII  | 12  | Saturn  | Libra         | Unclassified           | 192.2                    |
| 114                                | VII  | 19  | Mercury | Libra         | Unclassified           | 200.07                   |
| 114                                | VIII | 25  | Venus   | Sagittarius   | Unclassified           | 260.91                   |
| 114                                | VIII | 27  | Mercury | Sagittarius   | Unclassified           | 242.35                   |
| 114                                | X    | 25  | Mercury | Aquarius      | Unclassified           | 320.79                   |
| 114                                | X    | 28  | Jupiter | Aquarius      | Unclassified           | 323.04                   |
| 114                                | XI   | 14  | Mercury | Aquarius      | Unclassified           | 307.4                    |
| 114                                | XII  | 3   | Jupiter | Pisces        | Beginning              | 331.21                   |
| 114                                | XII  | 13  | Mercury | Pisces        | Unclassified           | 333                      |
| 118                                | II   | 15  | Jupiter | Gemini        | Unclassified           | 68.5                     |
| 118                                | VII  | ~15 | Venus   | Libra         | Unclassified           | 214                      |
| 118                                | VIII | 2   | Venus   | Libra         | Unclassified           | 204.8                    |
| 118                                | VIII | ~9  | Saturn  | Scorpio       | Unclassified           | 233.54                   |
| 118                                | VIII | ~29 | Mercury | Sagittarius   | Unclassified           | 256.76                   |
| 118                                | IX   | 14  | Saturn  | Scorpio       | End                    | 237.49                   |
| 120                                | IV   | 25  | Jupiter | Leo           | Unclassified           | 134.46                   |
| 120                                | IV   | ~22 | Mercury | Cancer        | Unclassified           | 105.01                   |
| 120                                | VI   | 7   | Mars    | Leo           | End                    | 150.04                   |
| 120                                | VIII | 8   | Mercury | Libra         | End                    | 208.92                   |

## Appendix E

| Date (Regnal year or Seleucid Era) |      |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|------------------------------------|------|-----|---------|---------------|------------------------|--------------------------|
| 120                                | VIII | ~22 | Saturn  | Sagittarius   | Unclassified           | 256.33                   |
| 121                                | II   | ~6  | Mercury | Taurus        | End                    | 51.35                    |
| 121                                | III  | 16  | Mercury | Cancer        | Beginning              | 95.59                    |
| 121                                | IV   | ~17 | Mercury | Gemini        | Unclassified           | 88.57                    |
| 121                                | IX   | ~19 | Saturn  | Capricorn     | Beginning              | 267.54                   |
| 121                                | XII  | 27  | Mercury | Pisces        | Unclassified           | 332.87                   |
| 122                                | II   | ~8  | Mercury | Gemini        | Unclassified           | 75.96                    |
| 122                                | VII  | 1   | Mars    | Libra         | Beginning              | 175.95                   |
| 123                                | I    | 1   | Mercury | Taurus        | Beginning              | 30.72                    |
| 124                                | VIII | 3   | Mercury | Sagittarius   | Unclassified           | 256.77                   |
| 124                                | VIII | ~11 | Jupiter | Sagittarius   | Unclassified           | 257.39                   |
| 124                                | XI   | ~15 | Mercury | Pisces        | Unclassified           | 350.59                   |
| 124                                | XII  | 3   | Venus   | Pisces        | End                    | 355.29                   |
| 125                                | X    | 18  | Saturn  | Aquarius      | Unclassified           | 314.16                   |
| 125                                | XI   | 9   | Jupiter | Aquarius      | Unclassified           | 301.67                   |
| 125                                | XII  | 1   | Mercury | Pisces        | End                    | 358.77                   |
| 126                                | XII  | 22  | Saturn  | Pisces        | Beginning              | 331.63                   |
| 128                                | II   | ~13 | Venus   | Gemini        | Unclassified           | 64.76                    |
| 128                                | II   | 30  | Venus   | Gemini        | Beginning              | 55.67                    |
| 129                                | I    | 23  | Saturn  | Pisces        | End                    | 359.24                   |
| 129                                | I    | ~14 | Venus   | Aries         | End                    | 27.7                     |
| 129                                | II   | 23  | Mercury | Gemini        | Unclassified           | 65.37                    |
| 129                                | VIII | 4   | Mercury | Libra         | Unclassified           | 202.86                   |
| 129                                | X    | 17  | Mercury | Capricorn     | Unclassified           | 282.6                    |
| 133                                | XI   | 11  | Mercury | Pisces        | Unclassified           | 330.63                   |
| 133                                | XII  | 29  | Mercury | Pisces        | End                    | 350.92                   |
| 136                                | IX   | 1   | Mercury | Sagittarius   | End                    | 269                      |
| 143                                | V    | ~19 | Saturn  | Libra         | Beginning              | 182.07                   |
| 143                                | V    | 24  | Venus   | Virgo         | End                    | 180.64                   |
| 143                                | V    | 27  | Mercury | Virgo         | Unclassified           | 157.08                   |
| 143                                | VI   | ~16 | Mars    | Scorpio       | Beginning              | 214.37                   |
| 143                                | VI   | 23  | Mercury | Libra         | Beginning              | 189.47                   |
| 143                                | VI   | ~29 | Saturn  | Libra         | Unclassified           | 186.81                   |
| 143                                | VIII | ~15 | Mercury | Sagittarius   | Unclassified           | 268.34                   |
| 143                                | IX   | ~2  | Mercury | Capricorn     | Unclassified           | 275.57                   |
| 144                                | II   | 18  | Venus   | Taurus        | End                    | 52.82                    |
| 148                                | VIII | ~11 | Saturn  | Scorpio       | End                    | 238.73                   |
| 148                                | VIII | ~18 | Mercury | Scorpio       | Unclassified           | 216.76                   |
| 148                                | X    | 19  | Jupiter | Capricorn     | Unclassified           | 274.5                    |
| 148                                | X    | ~20 | Mercury | Aquarius      | Unclassified           | 302.89                   |
| 148                                | XII  | ~14 | Mercury | Aquarius      | End                    | 321.45                   |
| 148                                | XII  | 16  | Venus   | Pisces        | Unclassified           | 351.57                   |
| 148                                | XII  | 22  | Venus   | Pisces        | Unclassified           | 347.61                   |
| 150                                | I    | ~18 | Mercury | Taurus        | Unclassified           | 40.92                    |
| 150                                | I    | ~22 | Mars    | Taurus        | Unclassified           | 53.81                    |
| 150                                | V    | 8   | Saturn  | Sagittarius   | Unclassified           | 254.67                   |
| 150                                | V    | ~15 | Mercury | Virgo         | Unclassified           | 165.16                   |
| 150                                | VI   | ~7  | Mercury | Leo           | End                    | 150.36                   |
| 153                                | I    | ~2  | Venus   | Aries         | Unclassified           | 22                       |
| 153                                | V    | ~15 | Mercury | Leo           | Unclassified           | 133.48                   |
| 153                                | X    | 2   | Venus   | Capricorn     | Beginning              | 272.33                   |
| 165                                | IX   | ~19 | Mercury | Sagittarius   | Unclassified           | 266.12                   |
| 165                                | X    | 10  | Venus   | Aquarius      | Unclassified           | 308.33                   |

## Appendix E

| Date (Regnal year or Seleucid Era) |                 |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|------------------------------------|-----------------|-----|---------|---------------|------------------------|--------------------------|
| 165                                | X               | 25  | Mercury | Pisces        | Beginning              | 328.78                   |
| 167                                | VI              | ~17 | Venus   | Virgo         | End                    | 179.83                   |
| 167                                | VII             | ~27 | Mercury | Libra         | Unclassified           | 194.94                   |
| 167                                | IX              | ~1  | Mercury | Scorpio       | Unclassified           | 227.46                   |
| 170                                | I               | ~23 | Mercury | Taurus        | Unclassified           | 35.37                    |
| 170                                | VI <sub>2</sub> | ~8  | Mercury | Virgo         | Unclassified           | 173.37                   |
| 170                                | VI <sub>2</sub> | ~20 | Jupiter | Scorpio       | Beginning              | 210.12                   |
| 170                                | VII             | 22  | Jupiter | Scorpio       | Unclassified           | 217.25                   |
| 170                                | VIII            | ~17 | Mercury | Sagittarius   | Unclassified           | 265.94                   |
| 170                                | XII             | ~11 | Mercury | Aries         | Unclassified           | 17.35                    |
| 171                                | IV              | ~4  | Venus   | Cancer        | End                    | 122.98                   |
| 171                                | IV              | 19  | Venus   | Cancer        | Unclassified           | 114.07                   |
| 171                                | IX              | ~7  | Jupiter | Sagittarius   | Unclassified           | 249.45                   |
| 171                                | XI              | 14  | Mercury | Pisces        | Unclassified           | 343.61                   |
| 175                                | VII             | 6   | Mercury | Virgo         | Unclassified           | 170.97                   |
| 175                                | VII             | ~10 | Mars    | Scorpio       | Unclassified           | 217.44                   |
| 175                                | VII             | ~13 | Saturn  | Scorpio       | Beginning              | 211.51                   |
| 175                                | X               | 10  | Mercury | Capricorn     | Unclassified           | 290.17                   |
| 178                                | XI              | 21  | Mercury | Pisces        | Beginning              | 331.61                   |
| 178                                | XII             | ~16 | Mercury | Pisces        | End                    | 349.94                   |
| 179                                | VII             | ~29 | Mercury | Scorpio       | Beginning              | 212.93                   |
| 179                                | VIII            | ~15 | Saturn  | Sagittarius   | Unclassified           | 256.53                   |
| 179                                | IX              | ~13 | Mercury | Sagittarius   | Unclassified           | 259.26                   |
| 179                                | X               | ~14 | Mercury | Aquarius      | Unclassified           | 312.08                   |
| 179                                | XII             | 14  | Mars    | Aries         | Unclassified           | 16.49                    |
| 179                                | XII             | 29  | Mercury | Pisces        | Unclassified           | 352.61                   |
| 182                                | I               | ~26 | Mercury | Taurus        | End                    | 59.34                    |
| 182                                | IV              | 14  | Mercury | Leo           | Unclassified           | 136                      |
| 182                                | VI              | ~9  | Mars    | Leo           | Unclassified           | 147.75                   |
| 182                                | VI              | ~22 | Mercury | Virgo         | Unclassified           | 167.35                   |
| 187                                | II              | 22  | Mercury | Cancer        | Beginning              | 90.6                     |
| 187                                | III             | ~22 | Mercury | Gemini        | Unclassified           | 83.73                    |
| 187                                | III             | ~27 | Venus   | Cancer        | Unclassified           | 118                      |
| 187                                | VI              | 1   | Mercury | Libra         | Unclassified           | 192.96                   |
| 187                                | VI              | 10  | Mercury | Libra         | Unclassified           | 201.88                   |
| 187                                | IX              | ~21 | Mercury | Capricorn     | Unclassified           | 293.44                   |
| 187                                | X               | 2   | Mercury | Aquarius      | Unclassified           | 307.32                   |
| 187                                | X               | ~28 | Mercury | Capricorn     | End                    | 295.71                   |
| 193                                | I               | 30  | Mercury | Gemini        | Beginning              | 61.08                    |
| 193                                | II              | 7   | Saturn  | Gemini        | Unclassified           | 64.89                    |
| 193                                | VII             | ~12 | Jupiter | Libra         | Unclassified           | 194.61                   |
| 193                                | VII             | 21  | Mercury | Libra         | Unclassified           | 198.77                   |
| 194                                | VIII            | ~17 | Venus   | Scorpio       | End                    | 238.49                   |
| 194                                | VIII            | ~23 | Jupiter | Scorpio       | Unclassified           | 225.34                   |
| 194                                | XII             | 14  | Mercury | Aquarius      | End                    | 323.1                    |
| 201                                | V               | ~4  | Mercury | Virgo         | Unclassified           | 158.19                   |
| 201                                | V               | ~14 | Saturn  | Virgo         | Unclassified           | 170.43                   |
| 201                                | V               | ~27 | Mercury | Virgo         | End                    | 186.73                   |
| 203                                | III             | 12  | Mercury | Cancer        | Unclassified           | 108.76                   |
| 203                                | III             | ~20 | Venus   | Cancer        | Unclassified           | 113.02                   |
| 203                                | IV              | ~15 | Mars    | Leo           | End                    | 149.56                   |
| 203                                | IV              | ~21 | Mercury | Virgo         | Beginning              | 157.81                   |
| 203                                | V               | 8   | Jupiter | Leo           | Unclassified           | 139.1                    |

## Appendix E

| Date (Regnal year or Seleucid Era) |                  |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|------------------------------------|------------------|-----|---------|---------------|------------------------|--------------------------|
| 203                                | VII              | ~10 | Saturn  | Libra         | Unclassified           | 198.6                    |
| 204                                | IV               | ~18 | Mercury | Leo           | Unclassified           | 141.34                   |
| 204                                | VIII             | 9   | Saturn  | Scorpio       | Beginning              | 210.65                   |
| 204                                | XI               | ~22 | Venus   | Pisces        | Beginning              | 331.92                   |
| 206                                | I                | ~24 | Mercury | Gemini        | Unclassified           | 61.96                    |
| 206                                | III              | ~6  | Mercury | Cancer        | Unclassified           | 101.85                   |
| 206                                | V                | ~28 | Venus   | Virgo         | End                    | 187.19                   |
| 206                                | VII              | ~14 | Jupiter | Scorpio       | Unclassified           | 223.81                   |
| 206                                | VII              | ~15 | Saturn  | Scorpio       | Unclassified           | 228.73                   |
| 206                                | VII              | ~17 | Mercury | Libra         | Unclassified           | 201.57                   |
| 212                                | VIII             | 2   | Mercury | Libra         | End                    | 211.28                   |
| 212                                | IX               | 10  | Mercury | Sagittarius   | Unclassified           | 249.09                   |
| 212                                | X                | ~2  | Saturn  | Capricorn     | End                    | 297.3                    |
| 215                                | II               | ~1  | Mercury | Taurus        | End                    | 56.05                    |
| 216                                | V                | 20  | Mercury | Virgo         | Unclassified           | 161.03                   |
| 216                                | VI               | 16  | Mercury | Leo           | End                    | 146.73                   |
| 218                                | IV               | ~17 | Mars    | Leo           | Unclassified           | 135.91                   |
| 218                                | V                | ~4  | Mercury | Cancer        | End                    | 114                      |
| 218                                | V                | 20  | Venus   | Leo           | Unclassified           | 139.06                   |
| 218                                | V                | ~22 | Mercury | Leo           | Unclassified           | 137.81                   |
| 224                                | VI               | ~11 | Mercury | Leo           | End                    | 150.5                    |
| 224                                | XII <sub>2</sub> | 1   | Venus   | Aries         | Unclassified           | 4.89                     |
| 224                                | XII <sub>2</sub> | 16  | Mercury | Pisces        | End                    | 346.56                   |
| 225                                | V                | ~4  | Mercury | Leo           | Unclassified           | 133.29                   |
| 225                                | VIII             | 1   | Mercury | Scorpio       | Beginning              | 212.35                   |
| 225                                | VIII             | 28  | Venus   | Sagittarius   | Unclassified           | 247.7                    |
| 234                                | I                | ~5  | Mercury | Taurus        | Unclassified           | 31.44                    |
| 234                                | II               | ~13 | Mercury | Gemini        | Unclassified           | 71.37                    |
| 234                                | III              | 18  | Mercury | Gemini        | Unclassified           | 70.32                    |
| 234                                | IV               | ~2  | Mercury | Gemini        | End                    | 91.28                    |
| 234                                | V                | 13  | Mercury | Virgo         | Unclassified           | 164.54                   |
| 234                                | V                | ~13 | Venus   | Leo           | Unclassified           | 135.22                   |
| 234                                | VI               | 2   | Mercury | Virgo         | End                    | 186.08                   |
| 234                                | VII              | ~30 | Mercury | Libra         | Unclassified           | 208.59                   |
| 234                                | VIII             | ~2  | Venus   | Scorpio       | Unclassified           | 232.51                   |
| 234                                | VIII             | ~12 | Saturn  | Scorpio       | Unclassified           | 216.49                   |
| 234                                | XI               | ~28 | Mercury | Aquarius      | Unclassified           | 316                      |
| 238                                | III              | ~16 | Mercury | Leo           | Beginning              | 129.9                    |
| 238                                | III              | 17  | Jupiter | Cancer        | Unclassified           | 90.26                    |
| 249                                | I                | 26  | Saturn  | Aries         | End                    | 28.79                    |

## Appendix E2: Beginning and end data from the Goal-Year Texts

| Date (Seleucid Era) |                  |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|---------------------|------------------|-----|---------|---------------|------------------------|--------------------------|
| 8                   | VII              | 14  | Jupiter | Pisces        | Beginning              | 330.99                   |
| 10                  | I                | 19  | Jupiter | Taurus        | Unclassified           | 35.27                    |
| 15                  | V                | ~24 | Mars    | Virgo         | Unclassified           | 170.79                   |
| 15                  | XI               | ~25 | Mars    | Aquarius      | Unclassified           | 302.87                   |
| 17                  | VII              | ~7  | Mars    | Scorpio       | Unclassified           | 219.35                   |
| 19                  | X                | 26  | Jupiter | Aquarius      | End                    | 319.99                   |
| 20                  | XII <sub>2</sub> | 21  | Jupiter | Aries         | Unclassified           | 5.03                     |

| Date (Seleucid Era) |                  |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|---------------------|------------------|-----|---------|---------------|------------------------|--------------------------|
| 22                  | VI               | 2   | Saturn  | Leo           | Unclassified           | 148.73                   |
| 25                  | IV               | ~18 | Jupiter | Leo           | Unclassified           | 130.26                   |
| 32                  | IV               | 29  | Saturn  | Sagittarius   | Unclassified           | 252.97                   |
| 32                  | IX               | 19  | Saturn  | Sagittarius   | Unclassified           | 252.97                   |
| 35                  | I                | ~22 | Mercury | Gemini        | Beginning              | 58.79                    |
| 35                  | III              | 3   | Mercury | Cancer        | Unclassified           | 105.81                   |
| 35                  | IV               | 21  | Mercury | Cancer        | Unclassified           | 122.15                   |
| 35                  | IX               | 21  | Saturn  | Capricorn     | Unclassified           | 294.44                   |
| 35                  | X                | 23  | Mercury | Aquarius      | Unclassified           | 322.19                   |
| 35                  | XI               | 2   | Saturn  | Capricorn     | End                    | 298.86                   |
| 35                  | XI               | ~11 | Mercury | Aquarius      | Unclassified           | 309.22                   |
| 36                  | II               | ~8  | Saturn  | Aquarius      | Unclassified           | 305.84                   |
| 37                  | XI               | ~21 | Saturn  | Aquarius      | Unclassified           | 324.06                   |
| 45                  | I                | 18  | Mercury | Taurus        | Unclassified           | 38.11                    |
| 45                  | IV               | 9   | Mercury | Cancer        | Unclassified           | 114.09                   |
| 45                  | V                | 20  | Mercury | Virgo         | Beginning              | 161.84                   |
| 45                  | VI               | 14  | Mercury | Leo           | End                    | 147.06                   |
| 45                  | VII              | 6   | Mercury | Virgo         | Unclassified           | 174.18                   |
| 45                  | VIII             | 29  | Mercury | Sagittarius   | Unclassified           | 242.05                   |
| 45                  | IX               | 14  | Mercury | Sagittarius   | Unclassified           | 267.19                   |
| 45                  | IX               | ~26 | Mercury | Sagittarius   | Unclassified           | 254.08                   |
| 45                  | XI               | 10  | Mercury | Capricorn     | Unclassified           | 292.61                   |
| 45                  | XII <sub>2</sub> | ~10 | Mercury | Aries         | Unclassified           | 18.64                    |
| 49                  | II               | 27  | Mercury | Cancer        | Unclassified           | 88.31                    |
| 49                  | III              | ~20 | Mercury | Gemini        | End                    | 80.34                    |
| 49                  | VI               | 10  | Mercury | Libra         | Unclassified           | 199.61                   |
| 49                  | VII              | ~7  | Mercury | Libra         | Unclassified           | 188.77                   |
| 49                  | VIII             | 11  | Mercury | Scorpio       | Unclassified           | 225.54                   |
| 49                  | IX               | 22  | Mercury | Capricorn     | Unclassified           | 289.98                   |
| 49                  | XI               | 2   | Mercury | Capricorn     | Unclassified           | 294.27                   |
| 50                  | I                | 7   | Mercury | Taurus        | Beginning              | 27.34                    |
| 50                  | III              | 13  | Mercury | Gemini        | Beginning              | 61.75                    |
| 61                  | IX               | 27  | Mars    | Taurus        | Unclassified           | 50.28                    |
| 63                  | V                | ~22 | Saturn  | Capricorn     | Beginning              | 270.5                    |
| 64                  | VIII             | ~12 | Jupiter | Scorpio       | Unclassified           | 233.94                   |
| 64                  | IX               | 14  | Jupiter | Scorpio       | End                    | 241.23                   |
| 69                  | II               | 3   | Jupiter | Aries         | Unclassified           | 24.9                     |
| 73                  | I                | ~11 | Venus   | Taurus        | Unclassified           | 44.63                    |
| 73                  | X                | 10  | Venus   | Aquarius      | Unclassified           | 299.42                   |
| 76                  | I                | 2   | Mercury | Taurus        | Unclassified           | 37.27                    |
| 76                  | V                | 21  | Mercury | Virgo         | Unclassified           | 182.79                   |
| 76                  | VI               | 24  | Mercury | Virgo         | Unclassified           | 177.45                   |
| 76                  | VII              | ~25 | Mercury | Libra         | Unclassified           | 210.22                   |
| 76                  | IX               | 10  | Mercury | Capricorn     | Unclassified           | 279.97                   |
| 76                  | XI               | 24  | Mercury | Aquarius      | Unclassified           | 319.38                   |
| 76                  | XII              | 26  | Mercury | Aries         | Unclassified           | 19                       |
| 81                  | IV               | ~18 | Saturn  | Leo           | Unclassified           | 144.89                   |
| 81                  | V                | 25  | Saturn  | Leo           | End                    | 149.32                   |
| 83                  | I                | ~4  | Venus   | Aries         | Unclassified           | 16.39                    |
| 83                  | V                | 11  | Mercury | Leo           | End                    | 150                      |
| 83                  | V                | 13  | Venus   | Leo           | Unclassified           | 150.63                   |
| 83                  | VI               | ~1  | Saturn  | Virgo         | Unclassified           | 169.17                   |
| 83                  | VI               | 3   | Venus   | Leo           | Unclassified           | 140.07                   |

## Appendix E

| Date (Seleucid Era) |      |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|---------------------|------|-----|---------|---------------|------------------------|--------------------------|
| 83                  | VII  | 6   | Mercury | Virgo         | Unclassified           | 170.33                   |
| 83                  | VII  | 12  | Saturn  | Virgo         | Unclassified           | 174.07                   |
| 83                  | VIII | ~4  | Mercury | Libra         | End                    | 201.23                   |
| 83                  | X    | 10  | Mercury | Capricorn     | Unclassified           | 290.32                   |
| 83                  | X    | ~24 | Mercury | Capricorn     | Unclassified           | 276.35                   |
| 85                  | VI   | ~20 | Saturn  | Libra         | Unclassified           | 193.21                   |
| 87                  | VII  | ~2  | Jupiter | Libra         | End                    | 211.15                   |
| 88                  | III  | 3   | Venus   | Gemini        | Unclassified           | 76.45                    |
| 89                  | III  | 27  | Mars    | Aquarius      | Unclassified           | 325.23                   |
| 89                  | V    | 27  | Mars    | Aquarius      | Unclassified           | 314.43                   |
| 89                  | IX   | 7   | Jupiter | Capricorn     | Unclassified           | 278.17                   |
| 92                  | IV   | ~10 | Mars    | Leo           | Unclassified           | 142.01                   |
| 94                  | I    | 15  | Mercury | Aries         | Unclassified           | 356.86                   |
| 94                  | IV   | 2   | Mercury | Cancer        | Unclassified           | 108.55                   |
| 94                  | IV   | 26  | Mercury | Cancer        | Unclassified           | 98.56                    |
| 94                  | VII  | 12  | Mercury | Libra         | Unclassified           | 204.54                   |
| 94                  | VIII | 21  | Mercury | Sagittarius   | Unclassified           | 247.19                   |
| 94                  | IX   | 27  | Mercury | Aquarius      | Unclassified           | 305.54                   |
| 94                  | X    | ~18 | Mercury | Aquarius      | Unclassified           | 325.69                   |
| 94                  | XI   | 7   | Mercury | Aquarius      | Unclassified           | 312.47                   |
| 94                  | XII  | ~10 | Mercury | Pisces        | Unclassified           | 342.86                   |
| 96                  | I    | 7   | Mercury | Taurus        | Unclassified           | 29.75                    |
| 96                  | III  | 21  | Mercury | Gemini        | Unclassified           | 69.78                    |
| 96                  | IV   | 7   | Mercury | Gemini        | Unclassified           | 95.29                    |
| 96                  | V    | 11  | Mercury | Leo           | End                    | 157.07                   |
| 96                  | VI   | ~6  | Mercury | Virgo         | End                    | 185.34                   |
| 96                  | VII  | 2   | Mercury | Virgo         | Unclassified           | 172.96                   |
| 96                  | VIII | ~2  | Mercury | Libra         | Unclassified           | 206.88                   |
| 96                  | IX   | 18  | Mercury | Capricorn     | Unclassified           | 279.39                   |
| 96                  | X    | 21  | Mercury | Capricorn     | Unclassified           | 278.31                   |
| 97                  | V    | 30  | Jupiter | Virgo         | Unclassified           | 161.8                    |
| 98                  | V    | 23  | Mercury | Leo           | Unclassified           | 140.62                   |
| 99                  | XII  | ~17 | Saturn  | Pisces        | End                    | 359.27                   |
| 110                 | VII  | 29  | Jupiter | Libra         | Unclassified           | 196.45                   |
| 112                 | VI   | 27  | Saturn  | Virgo         | Unclassified           | 168.6                    |
| 114                 | IV   | 10  | Mercury | Cancer        | Unclassified           | 99.52                    |
| 115                 | VIII | 7   | Jupiter | Pisces        | Unclassified           | 340.02                   |
| 115                 | XII  | ~8  | Mars    | Pisces        | End                    | 357.21                   |
| 115                 | XII  | ~20 | Jupiter | Aries         | Beginning              | 0.54                     |
| 122                 | I    | 2   | Mercury | Taurus        | Unclassified           | 37.26                    |
| 122                 | X    | 15  | Mercury | Capricorn     | Unclassified           | 282.97                   |
| 122                 | XI   | ~17 | Mercury | Aquarius      | Unclassified           | 310.14                   |
| 123                 | I    | 1   | Mercury | Aries         | End                    | 30.72                    |
| 123                 | VII  | ~24 | Jupiter | Scorpio       | Unclassified           | 224.32                   |
| 123                 | VIII | 25  | Jupiter | Scorpio       | Unclassified           | 231.32                   |
| 125                 | IV   | 14  | Mercury | Leo           | Unclassified           | 142.91                   |
| 125                 | V    | 14  | Mercury | Leo           | Unclassified           | 130.63                   |
| 125                 | VI   | ~2  | Mercury | Virgo         | Beginning              | 156.69                   |
| 125                 | VIII | 1   | Mercury | Scorpio       | Unclassified           | 244.93                   |
| 125                 | VIII | 15  | Mercury | Sagittarius   | Unclassified           | 247.3                    |
| 125                 | X    | 8   | Mercury | Capricorn     | Unclassified           | 277.49                   |
| 125                 | XI   | 14  | Mercury | Pisces        | Unclassified           | 341.83                   |
| 125                 | XII  | ~1  | Mercury | Pisces        | End                    | 358.77                   |

## Appendix E

| Date (Seleucid Era) |                  |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|---------------------|------------------|-----|---------|---------------|------------------------|--------------------------|
| 127                 | III              | ~22 | Venus   | Cancer        | Unclassified           | 100.36                   |
| 127                 | VI               | 1   | Venus   | Libra         | Beginning              | 183.26                   |
| 129                 | II               | 28  | Mars    | Taurus        | Unclassified           | 38.22                    |
| 132                 | XI               | 30  | Venus   | Pisces        | Unclassified           | 352.09                   |
| 133                 | I                | 17  | Saturn  | Taurus        | Unclassified           | 49.47                    |
| 135                 | II               | 17  | Saturn  | Gemini        | Unclassified           | 79.25                    |
| 135                 | III              | 9   | Mercury | Gemini        | Unclassified           | 75.7                     |
| 135                 | V                | ~7  | Mercury | Virgo         | Unclassified           | 173.02                   |
| 135                 | VI               | 22  | Mercury | Virgo         | End                    | 179.84                   |
| 135                 | XI               | 24  | Mercury | Pisces        | Beginning              | 330.47                   |
| 136                 | II               | 10  | Venus   | Gemini        | Unclassified           | 61.81                    |
| 136                 | II               | 21  | Venus   | Gemini        | Beginning              | 55.21                    |
| 136                 | XI               | 5   | Venus   | Aquarius      | Unclassified           | 306.98                   |
| 140                 | I                | 15  | Venus   | Aries         | Unclassified           | 7.46                     |
| 140                 | I                | 16  | Mercury | Aries         | Unclassified           | 0.1                      |
| 140                 | II               | 17  | Mercury | Gemini        | Unclassified           | 61.63                    |
| 140                 | V                | 17  | Mercury | Leo           | Beginning              | 126.88                   |
| 140                 | XI               | 18  | Mercury | Capricorn     | End                    | 325.75                   |
| 142                 | II               | 13  | Mercury | Gemini        | Unclassified           | 70.05                    |
| 146                 | II               | 9   | Mercury | Gemini        | Unclassified           | 82.58                    |
| 146                 | VII              | 29  | Mercury | Scorpio       | Beginning              | 213.56                   |
| 146                 | IX               | ~5  | Mercury | Sagittarius   | Unclassified           | 252.36                   |
| 146                 | X                | 14  | Mercury | Aquarius      | Unclassified           | 318.38                   |
| 146                 | X                | 27  | Mercury | Pisces        | Beginning              | 335.48                   |
| 146                 | XII              | 23  | Mercury | Pisces        | End                    | 348.93                   |
| 148                 | I                | 26  | Mercury | Taurus        | Unclassified           | 46.98                    |
| 148                 | IV               | 7   | Mercury | Gemini        | Unclassified           | 80.72                    |
| 148                 | IV               | 23  | Mercury | Cancer        | Unclassified           | 108.03                   |
| 148                 | VI               | 4   | Mercury | Virgo         | Unclassified           | 176.82                   |
| 148                 | VII              | 18  | Mercury | Libra         | Beginning              | 182.02                   |
| 148                 | IX               | 21  | Saturn  | Sagittarius   | Beginning              | 243.37                   |
| 148                 | X                | 5   | Mercury | Capricorn     | Unclassified           | 290.11                   |
| 148                 | XI               | 10  | Mercury | Capricorn     | Unclassified           | 287.86                   |
| 148                 | XII              | 17  | Mercury | Pisces        | Unclassified           | 326.31                   |
| 148                 | XII <sub>2</sub> | 23  | Mercury | Taurus        | Unclassified           | 34.59                    |
| 152                 | II               | ~3  | Venus   | Taurus        | End                    | 57.55                    |
| 152                 | II               | 15  | Venus   | Taurus        | Unclassified           | 50.43                    |
| 152                 | V                | ~17 | Mercury | Leo           | Unclassified           | 141.41                   |
| 152                 | VIII             | 14  | Mercury | Scorpio       | Unclassified           | 223.14                   |
| 152                 | X                | ~26 | Venus   | Aquarius      | Beginning              | 301.86                   |
| 152                 | XI               | 1   | Mercury | Pisces        | Beginning              | 329.54                   |
| 152                 | XII              | 23  | Mercury | Pisces        | Unclassified           | 338.28                   |
| 153                 | II               | 2   | Jupiter | Taurus        | Unclassified           | 50.98                    |
| 154                 | II               | ~16 | Jupiter | Gemini        | Unclassified           | 84.09                    |
| 154                 | III              | 18  | Jupiter | Cancer        | Beginning              | 90.99                    |
| 156                 | II               | 2   | Mercury | Taurus        | End                    | 53.41                    |
| 156                 | III              | 13  | Mercury | Gemini        | Unclassified           | 58.97                    |
| 156                 | III              | ~25 | Mercury | Gemini        | Unclassified           | 80.09                    |
| 156                 | IV               | 24  | Mercury | Leo           | Unclassified           | 134.19                   |
| 156                 | V                | 26  | Mercury | Virgo         | Unclassified           | 173.11                   |
| 156                 | IX               | 11  | Mercury | Sagittarius   | End                    | 269.61                   |
| 156                 | X                | ~8  | Mercury | Sagittarius   | Unclassified           | 266.13                   |
| 156                 | XII              | 28  | Mercury | Aries         | Unclassified           | 11.59                    |

# Appendix E



| Date (Seleucid Era) |                  |     | Planet  | Zodiacal Sign | Beginning / end record | Babylonian longitude (°) |
|---------------------|------------------|-----|---------|---------------|------------------------|--------------------------|
| 156                 | XII <sub>2</sub> | ~26 | Mercury | Taurus        | Beginning              | 32.71                    |
| 160                 | I                | 29  | Venus   | Taurus        | End                    | 55.11                    |
| 160                 | II               | 11  | Venus   | Taurus        | Unclassified           | 48.05                    |
| 160                 | XII              | 29  | Venus   | Aries         | Unclassified           | 20.11                    |
| 161                 | I                | 21  | Mercury | Taurus        | Unclassified           | 47.9                     |
| 161                 | III              | 2   | Mercury | Gemini        | End                    | 83.67                    |
| 161                 | IV               | 1   | Mercury | Gemini        | Unclassified           | 80.11                    |
| 161                 | X                | 1   | Mercury | Capricorn     | Unclassified           | 291.25                   |
| 161                 | XI               | 4   | Mercury | Capricorn     | Unclassified           | 290.84                   |
| 163                 | III              | 13  | Saturn  | Gemini        | Beginning              | 63.1                     |
| 163                 | IV               | ~6  | Venus   | Leo           | Beginning              | 125.97                   |
| 163                 | XII              | ~20 | Venus   | Pisces        | Unclassified           | 346.36                   |
| 165                 | III              | 5   | Jupiter | Taurus        | End                    | 65.72                    |
| 176                 | I                | ~11 | Mercury | Taurus        | Unclassified           | 47.1                     |
| 176                 | II               | 23  | Mercury | Taurus        | End                    | 58.01                    |
| 176                 | II               | 29  | Mercury | Gemini        | Unclassified           | 68.47                    |
| 176                 | IV               | 2   | Mercury | Leo           | Unclassified           | 130.73                   |
| 176                 | VI               | 1   | Mercury | Virgo         | Unclassified           | 155.1                    |
| 176                 | VIII             | 19  | Mercury | Sagittarius   | Unclassified           | 268.4                    |
| 176                 | XII              | 5   | Mercury | Aries         | Unclassified           | 7.72                     |
| 177                 | VIII             | 4   | Saturn  | Scorpio       | Unclassified           | 234.62                   |
| 177                 | IX               | 6   | Saturn  | Scorpio       | End                    | 238.35                   |
| 179                 | II               | 8   | Mercury | Gemini        | Unclassified           | 74.15                    |
| 179                 | IV               | 16  | Mercury | Cancer        | Unclassified           | 106.7                    |
| 179                 | V                | ~5  | Mercury | Leo           | Unclassified           | 133.28                   |
| 184                 | I                | ~17 | Venus   | Taurus        | Unclassified           | 49.02                    |
| 184                 | X                | 7   | Venus   | Capricorn     | Unclassified           | 287.89                   |
| 184                 | XII              | 23  | Venus   | Aries         | Unclassified           | 20.56                    |
| 186                 | VI               | ~6  | Venus   | Leo           | End                    | 147.99                   |
| 186                 | VIII             | 23  | Venus   | Sagittarius   | Beginning              | 242.95                   |
| 190                 | III              | 19  | Mercury | Cancer        | Unclassified           | 113.33                   |
| 190                 | IV               | ~23 | Mercury | Leo           | Unclassified           | 154.85                   |
| 190                 | V                | 24  | Mercury | Leo           | Unclassified           | 142.17                   |
| 190                 | VI               | ~3  | Venus   | Libra         | Beginning              | 192.27                   |
| 190                 | VIII             | ~8  | Mercury | Sagittarius   | Unclassified           | 251.87                   |
| 190                 | VIII             | ~23 | Mercury | Sagittarius   | Unclassified           | 261.39                   |
| 190                 | IX               | ~7  | Mercury | Sagittarius   | Unclassified           | 247.16                   |
| 190                 | X                | ~13 | Mercury | Capricorn     | Unclassified           | 279.09                   |
| 190                 | XI               | 24  | Mercury | Pisces        | Unclassified           | 350.61                   |
| 190                 | XII              | ~17 | Mercury | Aries         | Unclassified           | 12.19                    |
| 214                 | VI               | 15  | Venus   | Virgo         | Unclassified           | 173.49                   |
| 217                 | VIII             | ~23 | Venus   | Sagittarius   | Unclassified           | 255.59                   |
| 217                 | VIII             | ~27 | Venus   | Sagittarius   | Unclassified           | 252.99                   |
| 228                 | II               | ~11 | Venus   | Gemini        | Unclassified           | 67.84                    |
| 228                 | XI               | ~10 | Venus   | Aquarius      | End                    | 325.46                   |
| 228                 | XI               | 15  | Venus   | Aquarius      | Unclassified           | 322.15                   |

### Appendix E3: Beginning and end data from the Normal Star Almanacs

| Date (Seleucid Era) |      |                 | Planet  | Zodiacal Sign | Beginning / end | Babylonian longitude (°) |
|---------------------|------|-----------------|---------|---------------|-----------------|--------------------------|
| 82                  | IV   | 16              | Mercury | Cancer        | Unclassified    | 110.35                   |
| 82                  | XI   | 10              | Mars    | Leo           | End             | 155                      |
| 82                  | XII  | 9               | Mercury | Pisces        | Beginning       | 326.57                   |
| 92                  | XII  | 21              | Venus   | Aries         | Beginning       | 2.88                     |
| 93                  | I    | 4               | Jupiter | Aries         | End             | 26.96                    |
| 93                  | II   | 22              | Mercury | Gemini        | Unclassified    | 75.49                    |
| 93                  | IV   | 8               | Mercury | Leo           | Unclassified    | 127.44                   |
| 93                  | X    | 29              | Saturn  | Capricorn     | Unclassified    | 287.91                   |
| 93                  | XI   | 17              | Venus   | Pisces        | Unclassified    | 330.68                   |
| 101                 | IV   | 1               | Mars    | Gemini        | End             | 90.22                    |
| 104                 | IX   | 7               | Jupiter | Aries         | Unclassified    | 11.44                    |
| 104                 | IX   | 12              | Mercury | Sagittarius   | End             | 268.74                   |
| 104                 | IX   | 22              | Mercury | Sagittarius   | Unclassified    | 256.94                   |
| 105                 | I    | 24              | Jupiter | Taurus        | Unclassified    | 39.08                    |
| 105                 | V    | 1               | Mercury | Leo           | Unclassified    | 133.86                   |
| 105                 | V    | 20              | Jupiter | Taurus        | End             | 56.69                    |
| 105                 | V    | 27              | Mercury | Virgo         | Unclassified    | 165.48                   |
| 108                 | IV   | 4               | Jupiter | Leo           | Unclassified    | 129.41                   |
| 108                 | IV   | 10              | Mercury | Cancer        | Unclassified    | 117.98                   |
| 108                 | IV   | 18              | Saturn  | Cancer        | Unclassified    | 116.91                   |
| 108                 | V    | 4               | Jupiter | Leo           | Unclassified    | 135.7                    |
| 108                 | IX   | 5               | Jupiter | Virgo         | Beginning       | 152.45                   |
| 108                 | IX   | 20              | Mercury | Capricorn     | Unclassified    | 296.04                   |
| 111                 | II   | 26              | Mercury | Gemini        | Unclassified    | 74.57                    |
| 111                 | III  | 13              | Mercury | Cancer        | Unclassified    | 108.74                   |
| 111                 | III  | 28              | Venus   | Cancer        | Unclassified    | 102.92                   |
| 111                 | IV   | 24              | Saturn  | Virgo         | Beginning       | 151.59                   |
| 111                 | V    | 19              | Mercury | Leo           | Unclassified    | 143.06                   |
| 111                 | VI   | 12              | Venus   | Libra         | Unclassified    | 193.38                   |
| 111                 | VI   | 12              | Mercury | Virgo         | Unclassified    | 172.44                   |
| 111                 | VIII | 10              | Mercury | Sagittarius   | Unclassified    | 257.78                   |
| 111                 | X    | 1               | Saturn  | Virgo         | Unclassified    | 163.17                   |
| 111                 | XI   | 20              | Mercury | Pisces        | Unclassified    | 349.65                   |
| 111                 | XII  | 10              | Jupiter | Sagittarius   | Unclassified    | 244.63                   |
| 111                 | XII  | 16              | Mercury | Aries         | Unclassified    | 13.99                    |
| 111                 | XII  | 28              | Mars    | Pisces        | End             | 351.59                   |
| 116                 | IV   | 14              | Mercury | Leo           | Unclassified    | 147.52                   |
| 116                 | IV   | 26              | Jupiter | Aries         | End             | 26.42                    |
| 116                 | IX   | 16              | Mercury | Capricorn     | Unclassified    | 285.51                   |
| 116                 | IX   | 27              | Mercury | Capricorn     | Unclassified    | 273.92                   |
| 137                 | IV   | 26              | Saturn  | Cancer        | Unclassified    | 109.59                   |
| 137                 | VIII | 29              | Saturn  | Cancer        | End             | 118.07                   |
| 158                 | I    | 10              | Mercury | Aries         | Beginning       | 5.22                     |
| 158                 | IV   | 20 <sup>p</sup> | Saturn  | Pisces        | End             | 358.68                   |
| 158                 | VI   | 5               | Mercury | Leo           | End             | 155.82                   |
| 172                 | II   | 13              | Saturn  | Virgo         | Unclassified    | 169.69                   |
| 172                 | V    | 2               | Mercury | Cancer        | Unclassified    | 113.04                   |
| 172                 | VI   | 2               | Saturn  | Virgo         | End             | 176.36                   |
| 172                 | X    | 1               | Mercury | Sagittarius   | Unclassified    | 261.88                   |
| 173                 | VIII | 21 <sup>p</sup> | Mercury | Sagittarius   | Beginning       | 241.51                   |
| 173                 | VIII | 21 <sup>p</sup> | Mars    | Sagittarius   | Beginning       | 248.67                   |

| Date (Seleucid Era) |                 |    | Planet  | Zodiacal Sign | Beginning / end | Babylonian longitude (°) |
|---------------------|-----------------|----|---------|---------------|-----------------|--------------------------|
| 173                 | X               | 5  | Venus   | Aquarius      | Unclassified    | 303.89                   |
| 173                 | X               | 17 | Mercury | Aquarius      | End             | 324.58                   |
| 173                 | X               | 23 | Mars    | Aquarius      | Beginning       | 296.09                   |
| 173                 | XI              | 5  | Saturn  | Libra         | Unclassified    | 199.64                   |
| 173                 | XI              | 11 | Mercury | Aquarius      | Unclassified    | 310.56                   |
| 173                 | XII             | 12 | Mercury | Pisces        | Unclassified    | 340.32                   |
| 188                 | I               | 7  | Mercury | Taurus        | Unclassified?   | 33.49                    |
| 188                 | I               | 10 | Jupiter | Taurus        | Beginning       | 31.05                    |
| 188                 | I               | 14 | Saturn  | Aries         | Beginning       | 0.06                     |
| 188                 | II              | 12 | Jupiter | Taurus        | Unclassified    | 38.5                     |
| 188                 | II              | 13 | Mercury | Gemini        | Unclassified    | 70.81                    |
| 188                 | III             | 17 | Mercury | Gemini        | Unclassified    | 67.95                    |
| 188                 | VI              | 29 | Mercury | Virgo         | Unclassified?   | 175.28                   |
| 188                 | VII             | 30 | Mercury | Libra         | Unclassified    | 205.39                   |
| 188                 | X               | 8  | Mercury | Aquarius      | Beginning       | 290.63                   |
| 188                 | X               | 20 | Mercury | Capricorn     | Unclassified    | 278.94                   |
| 188                 | XI              | 28 | Mercury | Aquarius      | Unclassified    | 314.34                   |
| 188                 | XI              | 29 | Venus   | Pisces        | Unclassified    | 338.01                   |
| 188                 | XII             | 1  | Venus   | Pisces        | Unclassified    | 336.54                   |
| 188                 | XII             | 26 | Saturn  | Aries         | Unclassified    | 8.44                     |
| 189                 | II              | 4  | Mercury | Taurus        | Unclassified    | 50.9                     |
| 189                 | II              | 25 | Jupiter | Gemini        | Unclassified    | 65.26                    |
| 189                 | III             | 12 | Mercury | Taurus        | End             | 52.44                    |
| 189                 | III             | 22 | Jupiter | Gemini        | Unclassified    | 71.38                    |
| 189                 | III             | 28 | Mercury | Gemini        | Unclassified    | 79.25                    |
| 189                 | IV              | 26 | Mercury | Leo           | Unclassified    | 131.65                   |
| 189                 | V               | 30 | Mercury | Virgo         | Unclassified    | 171.43                   |
| 189                 | VI              | 8  | Saturn  | Aries         | Unclassified    | 19.51                    |
| 189                 | VI              | 25 | Mercury | Virgo         | Unclassified    | 157.66                   |
| 189                 | VI <sub>2</sub> | 23 | Mercury | Libra         | Unclassified    | 186.23                   |
| 189                 | VI <sub>2</sub> | 26 | Jupiter | Gemini        | End             | 89.33                    |
| 189                 | VII             | 11 | Mars    | Cancer        | Unclassified    | 100.04                   |
| 189                 | VII             | 24 | Venus   | Scorpio       | Unclassified    | 221.25                   |
| 189                 | VIII            | 14 | Mercury | Sagittarius   | Unclassified    | 267.1                    |
| 189                 | IX              | 2  | Mercury | Capricorn     | Unclassified    | 275.23                   |
| 189                 | IX              | 5  | Saturn  | Aries         | Unclassified    | 13.21                    |
| 189                 | IX              | 12 | Mercury | Sagittarius   | Unclassified    | 263.62                   |
| 189                 | IX              | 28 | Venus   | Aquarius      | Beginning       | 301.26                   |
| 189                 | X               | 5  | Mars    | Gemini        | Unclassified    | 82.93                    |
| 189                 | X               | 24 | Jupiter | Gemini        | Unclassified    | 79.34                    |
| 189                 | X               | 26 | Mercury | Aquarius      | Unclassified    | 304.48                   |
| 189                 | XI              | 27 | Mercury | Aries         | Unclassified    | 3                        |
| 189                 | XII             | 19 | Saturn  | Aries         | Unclassified    | 22.07                    |
| 189                 | XII             | 26 | Mercury | Taurus        | Unclassified    | 30.92                    |
| 194                 | III             | 19 | Jupiter | Libra         | Unclassified    | 202.28                   |
| 194                 | IV              | 13 | Saturn  | Gemini        | Unclassified    | 84.25                    |
| 194                 | IV              | 23 | Mercury | Cancer        | Unclassified    | 108.7                    |
| 194                 | X               | 3  | Mercury | Capricorn     | Unclassified    | 290.18                   |
| 194                 | X               | 20 | Mercury | Aquarius      | Unclassified    | 302.57                   |
| 194                 | XI              | 8  | Mercury | Capricorn     | Unclassified    | 288.31                   |
| 194                 | XII             | 8  | Mars    | Pisces        | End             | 354.77                   |
| 194                 | XII             | 10 | Saturn  | Gemini        | Unclassified    | 84.49                    |
| 194                 | XII             | 15 | Mars    | Aquarius      | End             | 324.71                   |

## Appendix E

| Date (Seleucid Era) |     |                 | Planet  | Zodiacal Sign | Beginning / end | Babylonian longitude (°) |
|---------------------|-----|-----------------|---------|---------------|-----------------|--------------------------|
| 195                 | II  | 21 <sup>?</sup> | Saturn  | Cancer        | Beginning       | 92.37                    |
| 201                 | I   | 2               | Mercury | Taurus        | Unclassified    | 32.28                    |
| 201                 | II  | 1               | Saturn  | Virgo         | Unclassified    | 163.86                   |
| 201                 | II  | 11              | Mercury | Gemini        | Unclassified    | 73.85                    |
| 201                 | II  | 13              | Jupiter | Gemini        | Unclassified    | 69.73                    |
| 201                 | III | 12              | Jupiter | Gemini        | Unclassified    | 76.26                    |
| 201                 | III | 14              | Mercury | Gemini        | Unclassified    | 70.68                    |
| 201                 | III | 22              | Mars    | Cancer        | Unclassified    | 118.01                   |
| 201                 | IV  | 1               | Mercury | Cancer        | Unclassified    | 98.13                    |
| 201                 | V   | 5               | Mercury | Virgo         | Unclassified    | 159.69                   |
| 201                 | V   | 14              | Saturn  | Virgo         | Unclassified    | 170.43                   |
| 201                 | VI  | 24              | Saturn  | Virgo         | Unclassified    | 175.21                   |
| 201                 | VI  | 26              | Mercury | Virgo         | Unclassified    | 175.88                   |
| 201                 | VII | 8               | Mars    | Libra         | Unclassified    | 186.55                   |
| 201                 | VII | 11              | Jupiter | Cancer        | Unclassified    | 93.83                    |
| 201                 | IX  | 3               | Venus   | Sagittarius   | Unclassified    | 259.59                   |
| 201                 | IX  | 5               | Venus   | Sagittarius   | Unclassified    | 258.17                   |
| 201                 | IX  | 13              | Mercury | Capricorn     | Unclassified    | 282.22                   |
| 201                 | X   | 4               | Mercury | Aquarius      | Beginning       | 293.9                    |
| 201                 | X   | 14              | Mercury | Capricorn     | Unclassified    | 282.33                   |
| 201                 | XI  | 2               | Saturn  | Libra         | Beginning       | 182.19                   |
| 201                 | XI  | 11              | Jupiter | Gemini        | Unclassified    | 83.85                    |
| 201                 | XI  | 26              | Mercury | Aquarius      | Unclassified    | 318.55                   |
| 208                 | X   | 19              | Jupiter | Aquarius      | Beginning       | 299.01                   |
| 208                 | XII | 4               | Venus   | Aries         | Unclassified    | 3.76                     |
| 212                 | II  | 14              | Saturn  | Capricorn     | End             | 296.48                   |
| 212                 | III | 21              | Mercury | Cancer        | Unclassified    | 115.66                   |
| 212                 | IV  | 19              | Mercury | Cancer        | Unclassified    | 104.43                   |
| 234                 | IX  | 18              | Mercury | Capricorn     | Unclassified    | 282.64                   |
| 234                 | X   | 8               | Mercury | Aquarius      | Beginning       | 291.26                   |
| 234                 | XII | 10              | Saturn  | Scorpio       | Unclassified    | 223.41                   |

#### Appendix E4: Beginning and end data from the Almanacs

| Date (Seleucid Era) |                  |    | Planet  | Zodiacal Sign | Beginning / end | Babylonian longitude (°) |
|---------------------|------------------|----|---------|---------------|-----------------|--------------------------|
| 129                 | I                | 12 | Mercury | Taurus        | Unclassified    | 30.61                    |
| 129                 | I                | 21 | Venus   | Taurus        | Beginning       | 36.3                     |
| 129                 | I                | 24 | Jupiter | Taurus        | Unclassified    | 40.73                    |
| 129                 | II               | 21 | Mercury | Gemini        | Unclassified    | 66.27                    |
| 129                 | II               | 27 | Jupiter | Taurus        | Unclassified    | 48.36                    |
| 129                 | III              | 24 | Mercury | Gemini        | Unclassified    | 68.45                    |
| 129                 | IV               | 9  | Mercury | Gemini        | End             | 92.42                    |
| 129                 | V                | 11 | Mercury | Leo           | End             | 151.6                    |
| 129                 | V                | 15 | Saturn  | Aries         | Unclassified    | 4.72                     |
| 129                 | VII              | 1  | Jupiter | Gemini        | Unclassified    | 66.33                    |
| 129                 | XII <sub>2</sub> | 5  | Saturn  | Aries         | Unclassified    | 7.51                     |
| 129                 | XII <sub>2</sub> | 7  | Mercury | Aries         | Unclassified    | 14.36                    |
| 179                 | IV               | 14 | Venus   | Cancer        | Unclassified    | 112.64                   |
| 179                 | V                | 10 | Mercury | Leo           | Unclassified    | 142.73                   |
| 179                 | IX               | 5  | Jupiter | Leo           | End             | 147.48                   |
| 179                 | IX               | 21 | Saturn  | Sagittarius   | Unclassified    | 260.62                   |

| Date (Seleucid Era) |      |    | Planet  | Zodiacal Sign | Beginning / end           | Babylonian longitude (°) |
|---------------------|------|----|---------|---------------|---------------------------|--------------------------|
| 179                 | X    | 16 | Mercury | Aquarius      | Unclassified              | 315.64                   |
| 179                 | XI   | 11 | Mercury | Pisces        | Unclassified              | 331.27                   |
| 179                 | XII  | 14 | Mars    | Aries         | Unclassified              | 16.49                    |
| 183                 | II   | 20 | Mars    | Capricorn     | Unclassified              | 292.94                   |
| 183                 | IV   | 7  | Jupiter | Scorpio       | Unclassified              | 229.62                   |
| 183                 | VIII | 29 | Mercury | Sagittarius   | Unclassified              | 260.74                   |
| 183                 | IX   | 22 | Jupiter | Sagittarius   | Unclassified              | 253.66                   |
| 183                 | IX   | 27 | Mercury | Sagittarius   | Unclassified              | 253.57                   |
| 183                 | X    | 20 | Saturn  | Aquarius      | Beginning                 | 303.25                   |
| 183                 | XI   | 29 | Saturn  | Aquarius      | Unclassified              | 307.82                   |
| 183                 | XII  | 10 | Mercury | Pisces        | Unclassified              | 349.5                    |
| 190                 | IV   | 3  | Saturn  | Taurus        | Unclassified              | 33.18                    |
| 190                 | V    | 5  | Venus   | Libra         | Beginning                 | 183.83                   |
| 198                 | VII  | 11 | Mercury | Scorpio       | Unclassified              | 228.64                   |
| 198                 | IX   | 26 | Mercury | Sagittarius   | End                       | 271.54                   |
| 201                 | III  | 12 | Jupiter | Gemini        | Unclassified              | 76.26                    |
| 201                 | III  | 22 | Mars    | Cancer        | Unclassified              | 118.01                   |
| 201                 | V    | 27 | Mercury | Virgo         | Unclassified              | 186.73                   |
| 201                 | VI   | 24 | Saturn  | Virgo         | Unclassified              | 175.21                   |
| 201                 | VII  | 11 | Jupiter | Cancer        | Unclassified              | 93.83                    |
| 201                 | VII  | 26 | Mercury | Libra         | End                       | 209.46                   |
| 201                 | IX   | 3  | Venus   | Sagittarius   | Unclassified              | 259.59                   |
| 201                 | IX   | 13 | Mercury | Capricorn     | Unclassified              | 282.22                   |
| 201                 | X    | 4  | Mercury | Aquarius      | Beginning                 | 293.9                    |
| 201                 | X    | 14 | Mercury | Capricorn     | Unclassified              | 282.97                   |
| 201                 | XI   | 2  | Saturn  | Libra         | Beginning                 | 182.19                   |
| 201                 | XI   | 11 | Jupiter | Gemini        | Unclassified              | 83.85                    |
| 209                 | II   | 19 | Mercury | Taurus        | Unclassified              | 47.09                    |
| 209                 | III  | 5  | Mercury | Gemini        | Unclassified              | 73.49                    |
| 209                 | III  | 29 | Mercury | Leo           | Unclassified <sup>?</sup> | 121.26                   |
| 209                 | V    | 3  | Mercury | Virgo         | Unclassified              | 164.91                   |
| 209                 | IX   | 12 | Mercury | Sagittarius   | Unclassified              | 266.36                   |
| 209                 | XI   | 2  | Mercury | Aquarius      | Beginning                 | 299.41                   |
| 209                 | XI   | 8  | Mars    | Pisces        | Unclassified              | 336.79                   |
| 209                 | XI   | 9  | Jupiter | Aquarius      | End                       | 328.49                   |
| 209                 | XII  | 4  | Mercury | Pisces        | End                       | 357.24                   |
| 209                 | XII  | 10 | Jupiter | Pisces        | Unclassified              | 335.68                   |
| 234                 | III  | 8  | Saturn  | Libra         | Unclassified              | 205.86                   |
| 234                 | IV   | 1  | Mercury | Gemini        | End                       | 89.33                    |
| 234                 | IV   | 22 | Jupiter | Aries         | Unclassified              | 4.03                     |
| 234                 | V    | 10 | Mercury | Virgo         | Unclassified              | 160.24                   |
| 236                 | I    | 29 | Jupiter | Taurus        | Unclassified              | 52.2                     |
| 236                 | II   | 6  | Venus   | Gemini        | Unclassified              | 63.5                     |
| 236                 | II   | 20 | Jupiter | Taurus        | End                       | 56.78                    |
| 236                 | III  | 15 | Mercury | Cancer        | Unclassified              | 107.93                   |
| 236                 | IV   | 1  | Saturn  | Scorpio       | Unclassified              | 228.26                   |
| 236                 | IV   | 23 | Mercury | Leo           | End                       | 155.6                    |
| 236                 | V    | 21 | Mercury | Leo           | Unclassified              | 142.11                   |
| 236                 | VI   | 12 | Mercury | Virgo         | Unclassified              | 168.21                   |
| 236                 | VI   | 22 | Jupiter | Gemini        | Unclassified              | 74.6                     |
| 236                 | VII  | 21 | Saturn  | Scorpio       | Unclassified              | 234.86                   |
| 236                 | VII  | 25 | Mars    | Cancer        | Unclassified              | 95.39                    |
| 236                 | VIII | 8  | Mercury | Sagittarius   | Unclassified              | 253.69                   |

## Appendix E

| Date (Seleucid Era) |                  |    | Planet  | Zodiacal Sign | Beginning / end | Babylonian longitude (°) |
|---------------------|------------------|----|---------|---------------|-----------------|--------------------------|
| 236                 | VIII             | 23 | Mercury | Sagittarius   | Unclassified    | 261.36                   |
| 236                 | IX               | 7  | Mercury | Sagittarius   | Unclassified    | 247.09                   |
| 236                 | X                | 16 | Mars    | Gemini        | Unclassified    | 76.29                    |
| 236                 | X                | 19 | Jupiter | Gemini        | Unclassified    | 64.56                    |
| 236                 | X                | 23 | Mercury | Capricorn     | Unclassified    | 296.63                   |
| 236                 | XI               | 6  | Mercury | Aquarius      | Unclassified    | 317.37                   |
| 236                 | XI               | 6  | Venus   | Aquarius      | Unclassified    | 323.22                   |
| 236                 | XI               | 23 | Mercury | Pisces        | Unclassified    | 350.64                   |
| 236                 | XII              | 27 | Mercury | Aries         | Unclassified    | 7.53                     |
| 244                 | II               | 1  | Jupiter | Capricorn     | End             | 296.37                   |
| 301                 | I                | 20 | Mercury | Taurus        | Unclassified    | 46.3                     |
| 301                 | II               | 14 | Saturn  | Aquarius      | Unclassified    | 304.41                   |
| 301                 | II               | 20 | Mercury | Taurus        | End             | 51.2                     |
| 301                 | III              | I  | Mercury | Gemini        | Unclassified    | 67.58                    |
| 301                 | VI               | 2  | Mercury | Virgo         | Unclassified    | 153.93                   |
| 305                 | I                | 3  | Saturn  | Pisces        | Unclassified    | 348.82                   |
| 305                 | I                | 21 | Mars    | Virgo         | Unclassified    | 161.18                   |
| 305                 | II               | 5  | Mercury | Gemini        | Beginning       | 57.37                    |
| 305                 | III              | 12 | Mercury | Cancer        | Unclassified    | 97.63                    |
| 305                 | IV               | 16 | Mercury | Cancer        | Beginning       | 92.33                    |
| 305                 | IV               | 22 | Jupiter | Pisces        | End             | 357.73                   |
| 305                 | IV               | 29 | Saturn  | Pisces        | End             | 355.02                   |
| 305                 | V                | 2  | Mercury | Cancer        | Unclassified    | 118.77                   |
| 305                 | VII              | 27 | Mercury | Libra         | Unclassified    | 194.89                   |
| 305                 | VIII             | 5  | Venus   | Scorpio       | Unclassified    | 228.83                   |
| 305                 | VIII             | 13 | Venus   | Scorpio       | Unclassified    | 224.1                    |
| 305                 | VIII             | 19 | Jupiter | Pisces        | Unclassified    | 347.78                   |
| 305                 | VIII             | 21 | Saturn  | Pisces        | Unclassified    | 348.54                   |
| 305                 | IX               | 3  | Mercury | Scorpio       | Unclassified    | 235.27                   |
| 305                 | X                | 12 | Mercury | Aquarius      | Beginning       | 297.29                   |
| 305                 | X                | 26 | Mercury | Aquarius      | Unclassified    | 315.34                   |
| 305                 | XI               | 21 | Mercury | Aquarius      | Unclassified    | 301.64                   |
| 305                 | XII              | 9  | Saturn  | Pisces        | End             | 356.08                   |
| 305                 | XII              | 25 | Mercury | Pisces        | Unclassified    | 334.72                   |
| 305                 | XII <sub>2</sub> | 1  | Jupiter | Aries         | Unclassified    | 8.37                     |
| 305                 | XII <sub>2</sub> | 28 | Saturn  | Aries         | Unclassified    | 2.25                     |
| 305                 | XII <sub>2</sub> | 29 | Mercury | Taurus        | Unclassified    | 41.28                    |
| 372                 | I                | 4  | Mercury | Taurus        | Unclassified    | 33.46                    |
| 372                 | II               | 12 | Mercury | Gemini        | Unclassified    | 72.59                    |
| 372                 | II               | 26 | Mars    | Gemini        | Unclassified    | 79.71                    |
| 372                 | III              | 3  | Saturn  | Cancer        | Unclassified    | 96.35                    |
| 372                 | III              | 7  | Jupiter | Libra         | Unclassified    | 204.48                   |
| 372                 | III              | 7  | Mercury | Gemini        | Unclassified    | 64.49                    |
| 372                 | III              | 29 | Mercury | Cancer        | Beginning       | 91.3                     |
| 372                 | IV               | 11 | Saturn  | Cancer        | Unclassified    | 101.22                   |
| 372                 | V                | 10 | Mercury | Virgo         | Unclassified    | 163.36                   |
| 372                 | V                | 28 | Mars    | Leo           | Unclassified    | 142.93                   |
| 372                 | V                | 29 | Mercury | Libra         | Beginning       | 185.97                   |
| 372                 | VI               | 25 | Mercury | Virgo         | Unclassified    | 176.76                   |
| 372                 | VII              | 21 | Jupiter | Scorpio       | Unclassified    | 222.15                   |
| 372                 | VII              | 28 | Mercury | Libra         | Unclassified    | 208.72                   |
| 372                 | VIII             | 7  | Saturn  | Cancer        | Unclassified    | 109.36                   |
| 372                 | VIII             | 18 | Jupiter | Scorpio       | Unclassified    | 228.23                   |

## Appendix E

| Date (Seleucid Era) |     |    | Planet  | Zodiacal Sign | Beginning / end | Babylonian longitude (°) |
|---------------------|-----|----|---------|---------------|-----------------|--------------------------|
| 372                 | IX  | 15 | Mercury | Capricorn     | Unclassified    | 282.91                   |
| 372                 | IX  | 29 | Venus   | Capricorn     | Unclassified    | 279.58                   |
| 372                 | X   | 7  | Mercury | Capricorn     | Unclassified    | 291.04                   |
| 372                 | X   | 19 | Mercury | Capricorn     | Unclassified    | 280.34                   |
| 372                 | XII | 4  | Saturn  | Cancer        | Unclassified    | 102.59                   |
| 372                 | XII | 23 | Jupiter | Sagittarius   | Unclassified    | 245.99                   |

***Appendix F: a comparison of records in the Normal Star Almanacs with records in the Almanacs***

| Date (Seleucid Era) |       | Text         |            | Record  |
|---------------------|-------|--------------|------------|---|
| 92                  | [XII] | LBAT 1005    | Rev. 3     | The 21st, Venus' first appearance in the east in the beginning of Aries |
|                     |       | BM 40101+    | Rev. 11    | The 21st, Venus' first appearance <sup>2</sup> in the east in Aries     |
| 179                 | IV    | LBAT 1043-44 | Obv. 17    | The 14th, Venus in the east [...]                                       |
|                     |       | LBAT 1136    | Obv. 3     | The 14th, Venus' first appearance in the east in Cancer                 |
| 179                 | IV    | LBAT 1043-44 | Obv. 19    | [...x+]1 (end of month) Saturn stationary in Sagittarius                |
|                     |       | LBAT 1136    | Obv. 4     | (end of month) Saturn stationary in Sagittarius                         |
| 179                 | V     | LBAT 1043-44 | Obv. 23    | The 10th, Mercury in the east [...]                                     |
|                     |       | LBAT 1136    | Obv. 6     | The 10th, Mercury's last appearance in the east in Leo                  |
| 189                 | III   | LBAT **1055  | Obv. 14-15 | The 12th, Mercury's first appearance in the east in the end of Taurus   |
|                     |       | LBAT 1141-42 | Obv. 4     | The 12th, Mercury's first appearance in the east in the end of Taurus   |
| 189                 | III   | LBAT **1055  | Obv. 15-16 | The 22nd Jupiter's first appearance in Gemini                           |
|                     |       | LBAT 1141-42 | Obv. 5     | The 22nd Jupiter's first appearance in Gemini                           |
| 189                 | V     | LBAT **1055  | Obv. 31    | The 30th, Mercury's last appearance in the west in Virgo                |
|                     |       | LBAT 1141-42 | Obv. 10    | The 30th, Mercury's last appearance in the west in Virgo                |
| 201                 | II    | LBAT **1059  | Obv. 10    | The 11th, Mercury's last appearance in the west in Gemini               |
|                     |       | LBAT 1151    | Obv. 4     | 'The xth' (7th-11th), Mercury in the west in Gemini [...]               |
| 201                 | III   | LBAT **1059  | Obv. 15    | The 12th, Jupiter's first appearance in Gemini                          |
|                     |       | LBAT 1151    | Obv. 7     | The 12th, Jupiter's first appearance in Gemini                          |
| 201                 | III   | LBAT **1059  | Obv. 17    | The 22nd, Mars' last appearance in Cancer                               |
|                     |       | LBAT 1151    | Obv. 8     | The 22nd, Mars' last appearance in Cancer                               |
| 201                 | IV    | LBAT **1059  | Obv. 20    | The 1st, Mercury's last appearance in the east in Cancer                |
|                     |       | LBAT 1151    | Obv. 9     | The 1st, Mercury in the east [...]                                      |
| 201                 | V     | LBAT **1059  | Obv. 30    | The 27th, Mercury's last appearance in the west in Virgo                |
|                     |       | LBAT 1151    | Obv. 12    | The 27th, Mercury's last appearance in the west in Virgo                |
| 201                 | VI    | LBAT **1059  | Obv. 33    | The 24th, Saturn's first appearance in Virgo                            |
|                     |       | LBAT 1151    | Obv. 13    | The 24th, Saturn's first appearance in Virgo                            |



| Date (Seleucid Era) |     | Text        |            | Record   |
|---------------------|-----|-------------|------------|--|
| 201                 | VI  | LBAT **1059 | Obv. 33-34 | The 26th, Mercury's first appearance in the east in Virgo                      |
|                     |     | LBAT 1151   | Obv. 13    | [...(end of month) Mercu]ry's 'first appearance' in the east in Virgo          |
| 201                 | VII | LBAT **1059 | Rev. 36    | The 8th, Mars' first appearance in Libra                                       |
|                     |     | LBAT 1151   | Obv. 14    | The 8th, Mars' 'first appearance in Leo <sup>21</sup> [...]                    |
| 201                 | VII | LBAT **1059 | Rev. 37    | The 11th, Jupiter stationary in Cancer   |
|                     |     | LBAT 1151   | Obv. 15    | The 11th, Jupiter stationary in Cancer   |
| 201                 | VII | LBAT **1059 | Rev. 37    | The 26th, Mercury's last appearance in the east in the end of Libra            |
|                     |     | LBAT 1151   | Obv. 15    | The 26th, Mercury's last appearance in the east in the end of Libra            |
| 201                 | IX  | LBAT **1059 | Rev. 48    | The 3rd, Venus' last appearance in the west in Sagittarius                     |
|                     |     | LBAT 1151   | Rev. 3     | The 3rd, Venus' last appearance in the west in Sagittarius                     |
| 201                 | IX  | LBAT **1059 | Rev. 48    | The 5th, Venus' first appearance in the east in Sagittarius                    |
|                     |     | LBAT 1151   | Rev. 3     | The 6th, Venus in the east [first appearance...]                               |
| 201                 | IX  | LBAT **1059 | Rev. 49    | The 11th, Jupiter's acronychal rising  |
|                     |     | LBAT 1151   | Rev. 4     | The 11th, Jupiter's acronychal rising  |
| 201                 | IX  | LBAT **1059 | Rev. 50    | The 13th, Mercury's first appearance in the west in Capricorn                  |
|                     |     | LBAT 1151   | Rev. 4     | The 13th, Mercury's first appearance in the west in Capricorn                  |
| 201                 | X   | LBAT **1059 | Rev. 54    | The 4th, Mercury's last appearance in the west in the beginning of Aquarius(?) |
|                     |     | LBAT 1151   | Rev. 7     | The 4th, Mercury's last appearance in the west in the beginning of 'x' [...]   |
| 201                 | X   | LBAT **1059 | Rev. 54    | The 14th, Mercury's first appearance in the east in Capricorn(?)               |
|                     |     | LBAT 1151   | Rev. 7     | The 14th, [Mercu]ry's first appearance in the east in Capricorn                |
| 201                 | XI  | LBAT **1059 | Rev. 60    | The 2nd, Saturn stationary in the beginning of Libra                           |
|                     |     | LBAT 1151   | Rev. 8     | The 20th, Saturn in the beginning of Libra 'x'                                 |
| 201                 | XI  | LBAT **1059 | Rev. 60    | The 11th, Jupiter stationary in Gemini   |
|                     |     | LBAT 1151   | Rev. 9     | The 11th, Jupiter stationary in Gemini   |
| 201                 | XII | LBAT **1059 | Rev. 70    | The 29th, Mercury's first appearance in the west in Aries                      |
|                     |     | LBAT 1151   | Rev. 12    | The 29th, Mercury in the west in 'Aries' xx'                                   |
| 234                 | XII | BM 32247    | Rev. 19    | The 10th, Saturn stationary in Scorpio   |
|                     |     | LBAT 1164-5 | Rev. 10    | The 10th, Saturn stationary in Scorpio   |

***Appendix G: a comparison of records in the Goal-Year Texts with records in the non-mathematical predictive texts, to understand what “date corrections” are applied to the records when making predictions***

| Goal year (SE) | Text no.    |             | Month | Observation  |
|----------------|-------------|-------------|-------|--|
| 96             | 10          | Obv.' 22    | I     | The 7th, Mercury's first appearance in the west in the beginning of Taurus                 |
|                | LBAT **1007 | Obv. 1      | I     | 'The 14th <sup>1</sup> , Mercury in the west in the beginning of [...]                     |
| 96             | 10          | Obv.' 8     | I     | Night of the 17th first part Venus 4 ½ cubits above γ Geminorum                            |
|                | LBAT **1007 | Obv. 3      | I     | Night of the 16th first part Venus <sup>2</sup> 4 [cubits] above γ Geminorum               |
| 96             | 10          | 'Rev. 3'-4' | I     | Night of the 5th first part Mars, while moving back to the east, 2 ½ cubits below ε Leonis |
|                | LBAT **1007 | Obv. 4      | I     | 'Night of the <sup>1</sup> 21st first part Mars 3 cubits below <sup>2</sup> ε Leonis       |
| 96             | 10          | Obv.' 23    | I     | Night of the 25th first part Mercury 1 cubit 4 fingers below β Tauri                       |
|                | LBAT **1007 | Obv. 4      | I     | Night of the 24th first [part] Mercury below β Tauri [...]                                 |
| 96             | 10          | Obv.' 24    | I     | [...] first part Mercury 1 5/6 cubits above ζ Tauri  |
|                | LBAT **1007 | Obv. 5      | I     | Night of the 26th first part Mercury 1 1/3 cubits above ζ Tau(ri)                          |
| 96             | 10          | 'Rev. 4'    | I     | Night of the 25th first part Mars 14 fingers above α Leonis                                |
|                | LBAT **1007 | Obv. 6      | II    | Night of the 11th first part Mars 14 fingers above α Leonis                                |
| 96             | 10          | Obv.' 25    | II    | The 13th, Mercury's last appearance in the west in the beginning of Gemini                 |
|                | LBAT **1007 | Obv. 6      | II    | The 13th, Mercury's last appearance in the west in Gemini                                  |
| 96             | 10          | 'Rev. 4'-5' | II    | Night of the 9th first part Mars ½ cubit above ρ Leonis                                    |
|                | LBAT **1007 | Obv. 7      | II    | Night of the 25th first part Mars above ρ [Leonis ...]                                     |
| 96             | 10          | Obv.' 9     | III   | The 3rd, Venus' last appearance in the west in Gemini                                      |
|                | LBAT **1007 | Obv. 8      | II    | The 29th, Venus' 'last appearance <sup>21</sup> in the west in Gemini                      |

Appendix G

| Goal year (SE) | Text no.    |             | Month | Observation  |
|----------------|-------------|-------------|-------|--|
| 96             | 10          | 'Rev. 5'    | II    | Night of the 28th first part Mars 4 cubits below $\theta$ Leonis                   |
|                | LBAT **1007 | Obv. 9      | III   | Night of the 14th first part 'Mars' 4 'cubits' below $\theta$ Leonis               |
| 96             | 10          | 'Rev. 6'    | III   | [...] first part Mars 1 finger above $\beta$ Virginis, it came close               |
|                | LBAT **1007 | Obv. 11     | IV    | x first part Mars 1 finger above $\beta$ Virginis                                  |
| 96             | 10          | Obv.' 11    | IV    | Night of the 10+[xth last part] Venus 1 $\frac{1}{2}$ cubits [...] $\mu$ Geminorum |
|                | LBAT **1007 | Obv. 12     | IV    | Night of the 11th last part Venus 1 $\frac{1}{2}$ cubits below $\mu$ Geminorum     |
| 96             | 10          | Obv.' 12    | V     | [...] last part of the night Venus 5 $\frac{1}{2}$ cubits below $\alpha$ Geminorum |
|                | LBAT 1008   | Obv. 7      | V     | Night of the 1st last part Venus 5 $\frac{1}{2}$ cubits below $\alpha$ Geminorum   |
| 96             | 10          | 'Rev. 7'    | IV    | Night of the 29th first part Mars 1 cubit above $\alpha$ Virginis                  |
|                | LBAT **1007 | Obv. 11     | V     | Night of the 15th first part Mars above $\alpha$ Virgin[is ...]                    |
| 96             | 10          | 'Rev. 7'-8' | V     | Night of the 30th, 8 fingers [... $\alpha$ Lib]rae                                 |
|                | LBAT 1008   | Obv. 14     | VI    | Night of the 16th first part Mars 8 fingers below $\alpha$ Librae                  |
| 96             | 10          | Obv.' 15    | VI    | Night of the 30th last part Venus 4 cubits below $\theta$ Leonis                   |
|                | LBAT 1008   | Obv. 15-16  | VI    | Night of the 29th last part Venus [...] 4 cubits [...]                             |
| 96             | 10          | Obv.' 18    | IX    | Night of the 4th last part Venus 2 fingers above $\beta$ Scorp[is]                 |
|                | LBAT 1008   | Rev. 7      | IX    | Night of the 2nd last part Venus 2 'fingers' above $\beta$ Scorp[is]               |
| 96             | 10          | Obv.' 19    | IX    | [...] Venus 2 cubits above $\alpha$ Scorp[is]                                      |
|                | LBAT 1008   | Rev. 8      | IX    | [...]°last part Venus' 3 cubits above $\alpha$ Scorp[is]                           |
| 96             | 10          | Obv.' 19    | IX    | Night of the 21st last part Venus 1 cubit 4 fingers above $\theta$ Ophiuchi        |
|                | LBAT 1008   | Rev. 9      | IX    | Night of the '19th Venus' 1 cubit 4 fingers above $\theta$ Ophiuchi                |

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| Goal year (SE) | Text no.   |          | Month | Observation   |
|----------------|------------|----------|-------|---|
| 96             | 10         | Obv.' 20 | X     | [...] Venus 2 ½ cubits below β Capricorni; I watched, but I did not see β |
|                | LBAT 1008  | Rev. 15  | X     | Night of the '23rd' last part Venus 1 1/3 cubits below β Capricorni       |
| 105            | 14         | 'Obv. 4' | I     | Night of the 19th first part Mars [...] above η Geminorum                 |
|                | LBAT *1011 | Obv. 1   | I     | Night of the 5th first part Mars 20 fingers above η Geminorum             |
| 105            | 14         | 'Obv. 5' | I     | [...] Mars 20 fingers above μ Geminorum                                   |
|                | LBAT *1011 | Obv. 1   | I     | Night of the 9th first part Mars 20 fingers above μ Geminorum             |
| 105            | 14         | 'Obv. 5' | II    | Night of the 1st first part Mars [...] above γ Geminorum                  |
|                | LBAT *1011 | Obv. 2   | I     | Night of the 18th first part Mars 3 cubits above γ Geminorum              |
| 105            | 14         | 'Obv. 6' | II    | [Night of the xth first] part Mars 3 ½ cubits below α Geminorum           |
|                | LBAT *1011 | Obv. 4   | II    | [Night of the 1st] first part Mars 3 ½ cubits below α Geminorum           |
| 105            | 14         | 'Obv. 6' | II    | Night of the 23rd first part Mars 2 ½ cubits below β Geminorum            |
|                | LBAT *1011 | Obv. 5   | II    | Night of the 9th first part Mars below β Geminorum[...]                   |
| 105            | 14         | 'Obv. 3' | III   | The 23rd, Mars' last appearance in Cancer                                 |
|                | LBAT *1011 | Obv. 6   | II    | The 23rd, Mars' last appearance in Cancer                                 |
| 106            | 15         | Obv. 13  | V     | Night of the 10th last part Venus 3 fingers above α Leonis                |
|                | BM 41022+  | Obv. 8   | V     | Night of the 8th last part Venus 3 fingers above α Leonis                 |
| 106            | 15         | Obv. 21  | X     | The 29th, Mercury's [first appearance ...]                                |
|                | BM 41022+  | Rev. 15  | X     | 29th, Mercury's [first appearance ...]                                    |
| 106            | 15         | Obv. 16  | XII   | [... Venus] 3 cubits [above α Tau]ri                                      |
|                | LBAT 1015  | Rev. 6   | XII   | [...] first part Venus 3 cubits above α Tauri                             |

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| Goal year (SE) | Text no.     |                | Month | Observation   |
|----------------|--------------|----------------|-------|---|
| 107            | 18           | Rev.' 3        | I     | Night of the 17th first part Mars 2 [cubits] below $\alpha$ Gem                     |
|                | LBAT 1016-18 | Obv. 3         | II    | 3rd first part Mars 3 ½ cubits below $\alpha$ Geminorum                             |
| 107            | 16           | 'Obv.' 11'     | II    | Night of the 22nd first part Venus [...] below $\delta$ Cancrī                      |
|                | LBAT 1016-18 | Obv. 5-6       | II    | Night of the 19th first part Venus above [ $\gamma/\delta$ ] Cancrī? [...]          |
| 107            | 16           | 'Obv.' 21'     | III   | The 30th, [Mercury's] last appearance [in the west in] Cancer                       |
|                | LBAT 1016-18 | Obv. 13        | III   | The 29th, Mercury's last appearance in the west in Cancer                           |
| 107            | 16           | 'Obv.' 12'-13' | IV    | Night of the 7th first part Venus 5 <sup>2</sup> cubits below $\theta$ Leonis       |
|                | LBAT 1016-18 | Obv. 15        | IV    | 'Night of the' 6th first part Venus 4 cubits below $\theta$ Leonis                  |
| 107            | 16           | 'Obv.' 21'     | IV    | The 24th, Mercury's [first appearance] in [the east in ...]                         |
|                | LBAT 1016-18 | Obv. 16        | IV    | The 24th, 'Mercury's x first appearance' <sup>21</sup>                              |
| 107            | 18           | 'Obv. 5'       | IX    | Around the 18th, Saturn's acronychal rising   |
|                | LBAT 1016-18 | Rev. 3         | X     | The 13th, Saturn's acronychal rising  |
| 107            | 17           | 'Obv.' 1'      | X     | The 20th, Jupiter's acronychal rising   |
|                | LBAT 1016-18 | Rev. 3         | X     | The 20th, Jupiter's acronychal rising   |
| 107            | 16           | 'Obv.' 17'-18' | XI    | Night of the 11th [last part Venus] ½ cubit below $\beta$ Capricorni                |
|                | LBAT 1016-18 | Rev. 5         | XI    | Night of the 9th [...] 'x' Venus 2 cubits below $\beta$ [Cap]ricorni                |
| 107            | 16           | 'Obv.' 18'     | XI    | Night of the 25th last part Venus 1 cubit 8 fingers above $\gamma$ Capricorni       |
|                | LBAT 1016-18 | Rev. 6         | XI    | Night of the 22nd las[t part] Venus 1 cubit 8 fingers 'x' [...] $\gamma$ Capricorni |
| 107            | 16           | 'Obv.' 18'-19' | XI    | Night of the 26th last part Venus 1 cubit 10 fingers above $\delta$ Capricorni      |
|                | LBAT 1016-18 | Rev. 7         | XI    | Night of the 24th last part [...] 1 cubit 8 fingers [...] [ $\delta$ Caprico]rni?   |

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| Goal year (SE) | Text no.     |             | Month | Observation   |
|----------------|--------------|-------------|-------|---|
| 107            | 18           | 'Obv. 7'-8' | XII   | Night of the 26th first part Saturn 2 fingers above $\delta$ Cancr <sup>i</sup> |
|                | LBAT 1016-18 | Rev. 11     | XII   | 'x' Saturn 2 fingers above $\delta$ Cancr <sup>i</sup>                          |
| 120            | 21           | 'Obv.' 6'   | II    | The 21st, Venus' [last appearance] in the west in Leo                           |
|                | LBAT 1022    | Obv. 7      | II    | The 17th Venus' last appearance in the west in Gemini                           |
| 129            | 27           | Obv. `7     | I     | The 11th, Mercury's first appearance in the west in Taurus <sup>?</sup>         |
|                | LBAT 1123    | Obv. 1      | I     | The 12th, Mercury's first appearance in the west in Taurus                      |
| 129            | 27           | Obv. 19     | III   | The 26th <sup>?</sup> , Mercury's [first appearance] in the east ...            |
|                | LBAT 1123    | Obv. 6      | III   | The 24th, Mercury's first appearance in the east in Gemini                      |
| 129            | 26           | 'Obv.' 3'   | V     | The 11th, Mercury's first appearance in the west in the end of Leo              |
|                | LBAT 1123    | Obv. 9      | V     | The 11th, Mercury's first appearance in the west in the end of Leo              |
| 129            | 27           | Obv. 21     | [VII] | The 6th, Mercury's first appearance in the east in Virgo                        |
|                | LBAT 1123    | Obv. 12     | [VII] | The 5th, Mercury 'xxx' [...]  |
| 129            | 27           | Obv. 25     | XII2  | The 6th, Mer[cury's first appearance in the west in Aries]                      |
|                | LBAT 1123    | Rev. 4      | XII2  | The 7th, Mercury's first appearance in the west in Aries                        |
| 129            | 27           | Obv. 33     | XI    | The 20th <sup>?</sup> , Mars' acronychal rising                                 |
|                | LBAT 1123    | Rev. 1      | XI    | The 14th, Mars' acronychal rising   |
| 135            | 31           | Obv.' 11    | IX    | Night of the 3rd first part Venus 4 fingers above $\gamma$ Capricorni           |
|                | LBAT 1026    | Obv. 6      | IX    | [... $\gamma$ ] Capricorni 4 fingers  |
| 135            | 31           | Obv.' 12    | IX    | Night of the 5th first part Venus 4 fingers above $\delta$ Capricorni           |
|                | LBAT 1026    | Obv. 7      | IX    | [...]'Venus' 4 fingers above $\delta$ Capricorni                                |

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| Goal year (SE) | Text no.     |                | Month             | Observation  |
|----------------|--------------|----------------|-------------------|--|
| 175            | 54           | Obv.' 7        | VI                | Night of the 12th last part Jupiter, while moving back to the west, 4 cubits below $\alpha$ Arietis                                |
|                | LBAT 1041-2  | Obv. 15        | VI                | [...] 'x' Jupiter 4 'x' below $\alpha$ Arietis   |
| 175            | 54           | Obv.' 13-14    | VI                | The 17th, Venus' [first appearance in the west in ...] (ideal) first appearance on the 15th <sup>2</sup>                           |
|                | LBAT 1041-2  | Obv. 14        | VI                | The 11th, Venus' first appearance in Virgo   |
| 184            | 60           | Obv.' 29       | VIII              | Night of the 27 <sup>th</sup> last part Venus [..]. above $\theta$ Ophiuchi  |
|                | LBAT 1048    | Obv. 7         | VIII              | Night of the 25 <sup>th</sup> last part Venus above [ $\theta$ Ophiuchi ...]   |
| 184            | 60           | Obv. 4         | IX                | Night [...] 2 cubits [below] $\beta$ Capricorni  |
|                | LBAT 1047    | Line 9         | VIII <sup>2</sup> | [... first] part <sup>2</sup> Jupiter 2 1/2 cu[bits] below $\beta$ Capricorni [...]  |
| 184            | 60           | Obv.' 2-3      | IX                | Around the 12th, Jupiter's last appearance in Capricorn  |
|                | LBAT 1047    | Line 13        | IX <sup>2</sup>   | 12th Jupiter's last appearance in Capricorn  |
| 187            | 63           | Obv. 11        | ?                 | [...] Venus was 1 cubit 4 fingers below $\alpha$ Leonis  |
|                | LBAT 1049-50 | Obv. 9         | ?                 | Night of the 2nd last part Venus 1 cubit 4 fingers below $\alpha$ Leonis   |
| 192            | 68           | 'Obv.' 9'      | VI                | Night of the 7th last part Venus 5 cubits below $\theta$ Leonis  |
|                | LBAT 1056    | Obv. 5         | VI                | Night of the 5th last part Venus 5 cubits 'x' $\theta$ [Leonis <sup>2</sup> ]  |
| 192            | 68           | 'Obv.' 10'     | VI                | [Ni]ght of the 20+[xth last part] Venus 2/3 <sup>2</sup> cubit below $\gamma$ Virginis   |
|                | LBAT 1056    | Obv. 9         | VI                | [...] last part Venus 1/3 cubit below $\gamma$ 'Vir'ginis  |
| 192            | 68           | 'Obv.' 23'     | VII               | [... Saturn] 6 fingers above $\zeta$ Tauri   |
|                | LBAT 1056    | Rev. 3         | VII               | [...] 21st last part Saturn 6 fingers above [ $\zeta$ ] Tauri <sup>2</sup>   |
| 192            | 68           | 'Obv.' 16'-17' | VII               | The 29th, Mercury's first appearance in the east in the beginning of Scorpio [...] ideal first appearance on the 27th <sup>2</sup> |
|                | LBAT 1056    | Rev. 4         | VII               | The 24th, Mercury in the east in Scor[pio ...]   |

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| Goal year (SE) | Text no.  |            | Month | Observation  |
|----------------|-----------|------------|-------|--|
| 192            | 68        | 'Obv.' 11' | VII   | Night of the 29th last part Venus 2 ½ cubits below β Librae                              |
|                | LBAT 1056 | Rev. 5     | VII   | [Night] of the 27th last part Venus 2 ½ cubits below β Librae                            |
| 192            | 68        | 'Obv.' 23' | VIII  | The 11th, Saturn's acronychal rising   |
|                | LBAT 1056 | Rev. 7     | VIII  | The 6th, Saturn's acronychal rising  |
| 192            | 68        | 'Obv.' 11' | VIII  | Night of the 10th last part Venus 8 fingers above β Scorpii                              |
|                | LBAT 1056 | Rev. 7-8   | VIII  | Night of the 8th last part Venus 'above' β [Scorpii? ...]                                |
| 194            | 69        | Obv. 1     | I     | Around the 15th, Jupiter's acronychal [rising ...]                                       |
|                | LBAT 1057 | Obv. 2     | I     | The 16th, Jupiter's acronychal [rising ...]  |
| 194            | 69        | Obv. 21    | II    | Night of the 2nd first part Mercury 1 ½ cubits below β Tauri                             |
|                | LBAT 1057 | Obv. 5     | II    | Night of the 1st first part Mercury 'xxx' below [β] Tauri                                |
| 194            | 69        | Obv. 8     | II    | Night of the 4th last part Venus 4 cubits below η Piscium                                |
|                | LBAT 1057 | Obv. 5-6   | II    | Night of the 2nd last part Venus 4 cubits below [η] Piscium                              |
| 194            | 69        | Obv. 9     | II    | Night of the 9th last part Venus 5 cubits below β Arietis                                |
|                | LBAT 1057 | Obv. 7     | II    | Night of the 8th last part Venus '4' [...] below β Arietis                               |
| 194            | 69        | Obv. 22    | II    | Night of the 9th first part Mercury 1 cubit 4 fingers above η Geminorum                  |
|                | LBAT 1057 | Obv. 8     | II    | Night of the 9th first part Mercury 1 'cubit x' fingers <sup>2</sup> above [η] Geminorum |
| 194            | 69        | Obv. 22    | II    | Night of the 11th first part Mercury 1 cubit 4 fingers above μ Geminorum                 |
|                | LBAT 1057 | Obv. 8     | II    | Night of the 11th first part Mercury 1 cubit 4 fingers <sup>2</sup> above μ Geminorum    |
| 194            | 69        | Obv. 22-23 | II    | Night of the 13th last part Venus 6 <sup>2</sup> [cubits] below α Arietis                |
|                | LBAT 1057 | Obv. 8     | II    | Night of the 12th last part 'Venus' 6 cubits below α Arietis                             |

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| Goal year (SE) | Text no.  |            | Month               | Observation   |
|----------------|-----------|------------|---------------------|---|
| 194            | 69        | Obv. 6     | [II <sup>2</sup> ]  | Jupiter, while moving back to the east, was 3 cubits below $\beta$ Librae                                     |
|                | LBAT 1057 | Obv. 9-10  | II                  | Night of the 13th first part Jupiter 3 cubits below $\beta^2$ Librae  |
| 194            | 69        | Obv. 10    | III                 | Night of the 10th last part Venus 2 cubits above $\alpha$ Tauri   |
|                | LBAT 1057 | Obv. 13    | III                 | Night of the 9th last part Venus 2 cubits above $\alpha$ Tauri  |
| 194            | 69        | Obv. 10    | III                 | Night of the 20th last part Venus 2 $\frac{1}{2}$ cubits below $\beta$ Tauri                                  |
|                | LBAT 1057 | Obv. 13-14 | III                 | Night of the 19th <sup>2</sup> last part Venus 2 $\frac{1}{2}$ cubits below $\beta$ Tauri                     |
| 194            | 69        | Obv. 1-2   | [III <sup>2</sup> ] | The 19th, Jupiter became stationary to the west, [nn] cubits behind $\beta$ Librae, 3 cubits low to the south |
|                | LBAT 1057 | Obv. 14    | III                 | The 19th, Jupiter stationary in Libra   |
| 194            | 69        | Obv. 11    | IV                  | Night of the 1st [last part Ve]nus 8 fingers above $\eta$ Geminorum   |
|                | LBAT 1057 | Obv. 15    | III                 | Night of the 30th last part Venus 8 fingers above $\eta$ Geminorum  |
| 194            | 69        | Obv. 34    | II                  | The 17th, Saturn's last appearance in Gemini  |
|                | LBAT 1057 | Obv. 12    | III                 | The 5th, Saturn 'xx' <sup>1</sup> [...last appearance <sup>2</sup> ]  |
| 194            | 69        | LE 4       | II                  | Night of the 20th first part Mars while moving back to the east 1 cubit below $\gamma$ Virginis               |
|                | LBAT 1057 | Obv. 13    | III                 | [5th-9th... Mars] 1 cubit below $\gamma$ Virginis   |
| 194            | 69        | Le 4-5     | III                 | Night of the 15th [first] part Mars 1 cubit above $\alpha$ Virginis   |
|                | LBAT 1057 | Obv. 17    | IV                  | Night of the 2 <sup>nd</sup> first part Mars 2 cubits above $\alpha$ Virginis                                 |
| 194            | 69        | Obv. 24    | IV                  | The 7th, Mercury's first appearance in the east in Gemini ... [(ideal) first appearance] on the 4th           |
|                | LBAT 1057 | Obv. 18    | IV                  | The 4th, Mercury's first appearance in the east 'xx' <sup>1</sup>   |
| 194            | 69        | Obv. 12    | IV                  | Night of the 6th last part Venus 2 <sup>2</sup> cubits above $\gamma$ Geminorum                               |
|                | LBAT 1057 | Obv. 18    | IV                  | Night of the 5th last part Venus 3 cubits above $\gamma$ Geminorum  |

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| Goal year (SE) | Text no.  |            | Month           | Observation  |
|----------------|-----------|------------|-----------------|--|
| 194            | 69        | Obv. 13    | IV              | Night of the 15th <sup>2</sup> [last part Venus] 4 cubits [below] $\alpha$ Geminorum                   |
|                | LBAT 1057 | Obv. 19    | IV              | Night of the 13th last part Venus 4 cubits below $\alpha$ Geminorum                                    |
| 194            | 69        | Obv. 35    | III             | The 21st, Saturn's first appearance in Gemini  |
|                | LBAT 1057 | Obv. 19    | IV              | The 13th, Saturn's first appearance in Gemini  |
| 194            | 69        | Obv. 13    | IV              | Night of the 18th last part Venus 5 cubits below $\beta$ Geminorum                                     |
|                | LBAT 1057 | Obv. 20    | IV              | Night of the 17th <sup>2</sup> last part Venus 3 cubits below $\beta$ Geminorum                        |
| 194            | 69        | Obv. 25    | IV              | The 23rd, Mercury's last appearance in the east in Cancer, I did not watch                             |
|                | LBAT 1057 | Obv. 21    | IV              | [...x+]3rd Mercury's last appearance in the east in Cancer   |
| 194            | 69        | Rev. 2     | VIII            | Night of the 16th first part Mars 2 cubits below $\beta$ Capricorni                                    |
|                | LBAT 1057 | Rev. 2     | IX              | Night of the <sup>2</sup> 2nd first part Mars below $\beta$ Capricorni [...]                           |
| 194            | 69        | Obv. 28    | X               | The 5th, Mercury's first appearance in the west in Capricorn, ... (ideal) first appearance on the 4th  |
|                | LBAT 1057 | Rev. 5     | X               | The 3rd, Mercury's first appearance in the west in Capricorn   |
| 194            | 69        | LE 1       | IX <sup>2</sup> | Around the 11th, Saturn's acronychal rising; I did not [watch]   |
|                | LBAT 1057 | Rev. 5     | X               | The 6th, Saturn's acronychal rising  |
| 194            | 69        | Obv. 7     | IX              | Night of the 24th last [part Jupiter] 1 cubit [above $\theta$ ] Ophiuchi                               |
|                | LBAT 1057 | Rev. 6     | X               | Night of the 17th last part Jupiter 'x' cubits above $\theta$ [Ophiuchi <sup>2</sup> ]                 |
| 194            | 69        | Obv. 28-29 | X               | [...Mercury's last appearance in the west] in Aquarius: from the 20th, when I watched I did not see it |
|                | LBAT 1057 | Rev. 6     | X               | The 20th, Mercury in the west in Aquarius 'x' [...]  |
| 194            | 69        | Obv. 29    | XI              | The 10th, Mercury's first appearance in the east in Capricorn, ... (ideal) first appearance on the 8th |
|                | LBAT 1057 | Rev. 8     | XI              | The 8th, Mercury's first appearance in the east in Capricorn   |

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| Goal year (SE) | Text no.  |            | Month | Observation  |
|----------------|-----------|------------|-------|--|
| 194            | 69        | Obv. 30    | XI    | Night of the 25th last part Mercury $\frac{1}{2}$ cubit above $\gamma$ Capricorni  |
|                | LBAT 1057 | Rev. 8-9   | XI    | Night of the 24th last part Mercury $\frac{1}{2}$ cubit above 'x' [...] Capricorni   |
| 194            | 69        | Obv. 31    | XI    | Night of the 27th last part Mercury $\frac{1}{2}$ cubit above $\delta$ Capricorni  |
|                | LBAT 1057 | Rev. 9-10  | XI    | Night of the 26th last part Mercury above $\delta$ [Capricorni ...]  |
| 194            | 69        | Obv. 15    | XI    | Night of the xth first part Venus $2\frac{1}{2}$ cubits below $\eta$ Piscium   |
|                | LBAT 1057 | Rev. 10    | XI    | Night of the 28th first part Venus $2\frac{1}{2}$ cubits below $\eta$ Piscium  |
| 194            | 69        | Obv. 15-16 | XII   | [... Venus] $3\frac{1}{2}$ cubits [below] $\beta$ Arietis  |
|                | LBAT 1057 | Rev. 12    | XII   | Night of the 5th first part Venus $3\frac{1}{2}$ cubits below [ $\beta$ ] Arietis  |
| 194            | 69        | LE 3       | XII   | Around the 8th, Mars' last appearance in the end of Pisces   |
|                | LBAT 1057 | Rev. 12    | XII   | The 8th, Mars' last appearance in the end of Pisces  |
| 194            | 69        | Obv. 16    | XII   | Ni[ght of the xth first part] Venus $4\frac{1}{2}$ cubits below $\alpha$ Arietis   |
|                | LBAT 1057 | Rev. 13    | XII   | Night of the 9th first part Venus $4\frac{1}{2}$ cubits below $\alpha$ Ari[etis]   |
| 194            | 69        | LE 2       | XI    | Around the 11th, Saturn became stationary to the west 6 fingers in front of $\alpha$ Geminorum                                   |
|                | LBAT 1057 | Rev. 13    | XII   | The 10th, Saturn stationary in Gemini  |
| 194            | 69        | Obv. 31-32 | XII   | The 17th, Mercury's last appearance in the east in Pisces, from the 14th in the end of Aquarius, when I watched I did not see it |
|                | LBAT 1057 | Rev. 14    | XII   | [x+]5th Mercury's last appearance in the east in the end of Aquarius   |
| 194            | 69        | Obv. 16    | XII   | Night of the 10+[xth first part Venus] $1\frac{1}{2}$ cubits [below $\eta$ Tau]ri  |
|                | LBAT 1057 | Rev. 14    | XII   | [... x+]5th first part Venus $1\frac{1}{2}$ cubits below $\eta$ Tauri  |
| 194            | 69        | Obv. 17    | XII2  | Night of the 14th <sup>?</sup> first part Venus [...] below [ $\beta$ ] Tauri  |
|                | LBAT 1057 | Rev. 19    | XII2  | Night of the 15th first part Venus below [ $\beta$ ] Tauri [...]   |

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| Goal year (SE) | Text no.    |              | Month | Observation   |
|----------------|-------------|--------------|-------|---|
| 201            | 73          | Obv. 31'     | I     | Night of the 9th first part Mercury 1 cubit above $\alpha$ Tauri                    |
|                | LBAT **1059 | Obv. 2-3     | I     | Night of the 8th first part Mercury 4 cubits above $\alpha$ Tauri                   |
| 201            | 73          | Rev. 36'     | I     | [...Mars] 4 cubits [above] $\gamma$ Geminorum                                       |
|                | LBAT **1059 | Obv. 3       | I     | Night of the 9th first part Mars 4 cubits above $\gamma$ Geminorum                  |
| 201            | 73          | Obv. 32'     | I     | Night of the 17th <sup>2</sup> first part [Mercury ...] below $\beta$ Tauri         |
|                | LBAT **1059 | Obv. 3-4     | I     | Night of the 16th first part Mercury 1 ½ cubits below $\beta$ Tauri                 |
| 201            | 73          | Obv. 32'     | I     | [Night of the 1]9th first part Mercury 1 ½ cubits above $\zeta$ Tauri               |
|                | LBAT **1059 | Obv. 4       | I     | Night of the 18th first part Mercury 1 ½ cubits above $\zeta$ Tauri                 |
| 201            | 73          | Obv. 33'     | I     | Night of the 10+[xth first part Mercury] 1 cubit 4 fingers [above $\eta$ Geminorum] |
|                | LBAT **1059 | Obv. 5       | I     | Night of the 25th first part Mercury 1 cubit 4 fingers above $\eta$ Geminorum       |
| 201            | 73          | Obv. 34'     | I     | Night of the 28th first part Mercury [...] above $\mu$ Ge[minorum]                  |
|                | LBAT **1059 | Obv. 5-6     | I     | Night of the 27th first part Mercury 1 cubit 4 fingers above $\mu$ Geminorum        |
| 201            | 73          | Rev. 37'     | I     | [...] Mars 3 ½ cubits below $\alpha$ Geminorum                                      |
|                | LBAT **1059 | Obv. 6       | I     | Night of the 28th first part Mars 3 ½ cubits below $\alpha$ Geminorum               |
| 201            | 73          | Obv. 34'-35' | II    | [Night of the xth first part Mercury] 4 cubits above $\gamma$ Geminorum             |
|                | LBAT **1059 | Obv. 8-9     | II    | Night of the 2nd first part Mercury 4 cubits above $\gamma$ Geminorum               |
| 201            | 73          | Rev. 37'     | I     | Night of the 21st first part Mars [...]   |
|                | LBAT **1059 | Obv. 10      | II    | Night of the 8th first part Mars 2 ½ cubits below $\beta$ Geminorum                 |
| 201            | 73          | Rev. 38'     | II    | [...] Mars ½ cubit above $\delta$ Cancrī  |
|                | LBAT **1059 | Obv. 14      | III   | Night of the 2nd first part Mars ½ cubit above $\delta$ Cancrī                      |

## Appendix G

| Goal year (SE) | Text no.    |              | Month | Observation  |
|----------------|-------------|--------------|-------|--|
| 201            | 73          | Obv. 1       | III   | The 13th, Jupiter's first appearance in Gemini   |
|                | LBAT **1059 | Obv. 15      | III   | The 12th, Jupiter's first appearance in Gemini   |
| 201            | 73          | Obv. 35'-36' | III   | [The xth, Mercury's first appearance in the east in Gemini], ... (ideal) first appearance on the 14th                  |
|                | LBAT **1059 | Obv. 15      | III   | The 14th Mercury's first appearance in the west in Gemini  |
| 201            | 73          | Rev. 17      | IV    | Night of the 12th first part Saturn while moving back to the west [...] fingers [below $\gamma$ Virginis]              |
|                | LBAT **1059 | Obv. 16      | III   | Night of the 20th first part Saturn 6 fingers below $\gamma$ Virginis  |
| 201            | 73          | Obv. 37'     | V     | Around the 5th, Mercury's first appearance in the west in Vir[go?], I did not watch                                    |
|                | LBAT **1059 | Obv. 26      | V     | The 5th, Mercury's first appearance in the west in Virgo   |
| 201            | 73          | Rev. 17-18   | V     | The 27th, Saturn's last appearance in Virgo, from the 23rd, when I watched I did not see it                            |
|                | LBAT **1059 | Obv. 27      | V     | The 14th, Saturn's last appearance in Virgo  |
| 201            | 73          | Obv. 37'     | V     | Around the 27th, [Mercury's last appearance in the west in ...]  |
|                | LBAT **1059 | Obv. 30      | V     | The 27th, Mercury's last appearance in the west in Virgo   |
| 201            | 73          | Rev. 18-19   | VII   | [The xth, Saturn's] first appearance [in Virgo...behind Mercu]ry to the east; ... (ideal) first appearance on the 12th |
|                | LBAT **1059 | Obv. 33      | VI    | The 24th, Saturn's first appearance in Virgo   |
| 201            | 73          | Obv. 38'     | VI    | The 28th, Mercury's [first appearance] in the east in Virgo ...  |
|                | LBAT **1059 | Rev. 37      | VI    | The 26th, Mercury's first appearance in the east in Virgo  |
| 201            | 73          | Obv. 38'     | VII   | [Night of the 6th <sup>2</sup> , last part Mercury] 2 cubits [above] $\alpha$ Virginis                                 |
|                | LBAT **1059 | Rev. 36      | VII   | Night of the 7th last part Mercury 2 cubits above $\alpha$ Virginis  |
| 201            | 73          | Rev. 39'     | VII   | [night of the xth] last part Mars 8 fingers below $\alpha$ Librae  |
|                | LBAT **1059 | Rev. 42      | VIII  | Night of the 2nd last part Mars 8 fingers below $\alpha$ Librae  |

## Appendix G

| Goal year (SE) | Text no.    |              | Month | Observation   |
|----------------|-------------|--------------|-------|---|
| 201            | 73          | Rev. 39'-40' | VII   | Night of the 23rd last part Mars [below $\beta$ Librae]   |
|                | LBAT **1059 | Rev. 42      | VIII  | Night of the 9th last part Mars 3 ½ cubits below $\beta$ Librae   |
| 201            | 73          | Rev. 40'     | VIII  | [Night of the xth last part Mars] 8 fingers below $\beta$ Scorpii   |
|                | LBAT **1059 | Rev. 44-46   | VIII  | Night of the 29th last part of the night Mars 8 fingers below $\beta$ Scorpii                               |
| 201            | 73          | Rev. 40'-41' | VIII  | Night of the 23rd last part Mars [...] above $\alpha$ Scorpii   |
|                | LBAT **1059 | Rev. 48      | IX    | Night of the 9th last part Mars 2 ½ cubits above $\alpha$ Scorpii   |
| 201            | 73          | Obv. 40'     | IX    | The 9th <sup>?</sup> Mercury's [first appearance] in the west in [Capricorn ...]                            |
|                | LBAT **1059 | Rev. 50      | IX    | The 13th, Mercury's first appearance in the west in Capricorn   |
| 201            | 73          | Rev. 41'     | IX    | [Night of the xth last part Mars] ½ cubit [above $\theta$ ] Ophiuchi  |
|                | LBAT **1059 | Rev. 50      | IX    | Night of the 25th last part Mars ½ cubit above $\theta$ Ophiuchi  |
| 201            | 73          | Rev. 1-2     | X     | [The xth, Mercury's first appearance] in the east in Capricorn,... (ideal) first appearance on the 14th     |
|                | LBAT **1059 | Rev. 54      | X     | The 14th, Mercury's first appearance in the east in Capricorn(?)  |
| 201            | 73          | Rev. 19-20   | IX    | Around until the 7th <sup>?</sup> Saturn became stationary to the east ... [behind $\alpha$ Virginis]       |
|                | LBAT **1059 | Rev. 60      | XI    | The 2nd, Saturn stationary in the beginning of Libra  |
| 201            | 73          | Rev. 41'     | XI    | Night of the 6th last part Mars 2 ½ cubits below $\beta$ Capricorni   |
|                | LBAT **1059 | Rev. 61      | XI    | Night of the 22nd last part Mars 2 ½ cubits below $\beta$ Capricorni  |
| 201            | 73          | Rev. 3       | XI    | The 28th, Mercury's last appearance in the east in Aquarius, from the 26th, when I watched I did not see it |
|                | LBAT **1059 | Rev. 61      | XI    | The 26th, Mercury's last appearance in the east in Capricorn  |
| 201            | 73          | Rev. 42'     | XII   | [Night of the x]+1st last part Mars ½ cubit above $\delta$ Capricorni                                       |
|                | LBAT **1059 | Rev. 68      | XII   | Night of the 17th last part Mars ½ cubit above $\delta$ Capricorni  |

## Appendix G

| Goal year (SE) | Text no.    |            | Month           | Observation  |
|----------------|-------------|------------|-----------------|--|
| 201            | 73          | Rev. 4     | I               | The 1st, Mercury's first appearance in the west in Aries, ..., (ideal) first appearance on the 30th of Month XII |
|                | LBAT **1059 | Rev. 70    | XII             | The 29th, Mercury's first appearance in the west in Aries  |
| 201            | 73          | Obv. 1     | III             | The 13th, Jupiter's first appearance in Gemini   |
|                | LBAT 1151   | Obv. 7     | III             | The 12th, Jupiter's first appearance in Gemini   |
| 201            | 73          | Rev. 18-19 | VII             | Saturn's first appearance [in Virgo]; (ideal) first appearance on the 12th                                       |
|                | LBAT 1151   | Obv. 13    | VI              | The 24th, Saturn's first appearance in Virgo   |
| 201            | 73          | Rev. 19    | IX              | Around until the 7th <sup>2</sup> , when Saturn became stationary to the east ...                                |
|                | LBAT 1151   | Rev. 4     | IX              | The 20th, 'Saturn' [...stationary <sup>2</sup> ]   |
| 201            | 73          | Rev. 1-2   | X               | [Mercury's] (ideal) first appearance on the 14th   |
|                | LBAT 1151   | Rev. 7     | X               | The 14th, [Mercury's] first appearance in the east in Capricorn  |
| 236            | 86          | Obv. 27    | II              | Around the 4th, Saturn's acronychal rising   |
|                | LBAT 1174   | Obv. 1     | I               | The 27th, Saturn's 'acronychal rising' <sup>1</sup>  |
| 236            | 86          | Obv. 12    | II              | Around the 11th, Venus' first appearance in the west in Gemini   |
|                | LBAT 1174   | Obv. 3     | II              | The 6th, Venus' 'first appearance' <sup>1</sup> in the west in Gemini  |
| 236            | 86          | Obv. 2     | II <sup>2</sup> | [Jupiter's] first appearance [...] (ideal) first appearance on the 19th  |
|                | LBAT 1174   | Obv. 4     | II              | The 20th, Jupiter's first appearance in the end of 'Taurus' <sup>2</sup>   |
| 236            | 86          | Obv. 20-21 | II              | Around the 20th, Mercury's last appearance in the east, omitted  |
|                | LBAT 1174   | Obv. 4     | II              | The 20th, Mercury's last appearance in the east, omitted   |
| 236            | 86          | Obv. 21    | III             | The 19th, Mercury's first appearance in the west in Cancer ... (ideal) first appearance on the 17th              |
|                | LBAT 1174   | Obv. 5     | III             | The 15th, Mercury's first appearance in the west in Cancer   |

## Appendix G

| Goal year (SE) | Text no.  |            | Month | Observation   |
|----------------|-----------|------------|-------|---|
| 236            | 86        | Obv. 27    | IV    | Until the 8th, when Saturn became stationary to the west...   |
|                | LBAT 1174 | Obv. 7     | IV    | The 1st, Saturn stationary in Scorpio   |
| 236            | 86        | Obv. 22    | IV    | Around the 23rd, Mercury's last appearance in the west in Leo                                       |
|                | LBAT 1174 | Obv. 8-9   | IV    | The 23rd, Mercury's last appearance in the west in the end of Leo                                   |
| 236            | 86        | Obv. 22    | V     | The 24th, Mercury's first appearance in the east in Leo ... (ideal) first appearance on the 21st    |
|                | LBAT 1174 | Obv. 10    | V     | The 21st, Mercury's first appearance in the east in Leo   |
| 236            | 86        | Obv. 23    | VI    | [last] appearance of Mercury in Virgo, when I watched from the 12th I did not see it                |
|                | LBAT 1174 | Obv. 11-12 | VI    | The 12th, Mercury's last appearance in the east in Virgo  |
| 236            | 86        | Obv. 23    | VIII  | Around the 8th, Mercury's first appearance in the west in Sagittarius, I did not watch              |
|                | LBAT 1174 | Rev. 1     | VIII  | The 8th, Mercury's first appearance in the east in Sagittarius                                      |
| 236            | 86        | Obv. 28    | VIII  | The 4th, Saturn's last appearance in Scorpio, from the 2nd when I watched I did not see it          |
|                | LBAT 1174 | Obv. 13    | VII   | The 21st, Saturn's last appearance in Scorpio   |
| 236            | 86        | Obv. 23-24 | VIII  | Around the 23rd, Mercury's last appearance in the west in Sagittarius, I did not watch              |
|                | LBAT 1174 | Rev. 2     | VIII  | The 23rd, Mercury's last appearance in the west in Sagittarius                                      |
| 236            | 86        | Obv. 38    | [IX]  | Around the 2nd, Mars' acronychal rising   |
|                | LBAT 1174 | Rev. 3     | IX    | The 6th, 'Mars' acronychal rising'  |
| 236            | 86        | Obv. 24    | IX    | Around the 7 <sup>th</sup> , Mercury's first appearance in the east in Sagittarius, I did not watch |
|                | LBAT 1174 | Rev. 3     | IX    | The 7th, Mercury's first appearance in the east in Sagittarius                                      |
| 236            | 86        | Obv. 24    | X     | Around the 13th, Mercury's last appearance in the east in Capricorn, I did not watch                |
|                | LBAT 1174 | Rev. 6     | X     | The 23rd, Mercury's last appearance in the east in Capricorn  |

## Appendix G



| Goal year (SE) | Text no.       |               | Month | Observation  |
|----------------|----------------|---------------|-------|--|
| 236            | 86             | Obv. 18       | XI    | Around the 10th, Venus' last appearance in the west in the end of Aquarius                   |
|                | LBAT 1174      | Rev. 7        | XI    | The 6th, Venus' last appearance in the west in Aquarius                                      |
| 236            | 86             | Obv. 19       | XI    | The 15th, Venus' first appearance in the east in Aquarius                                    |
|                | LBAT 1174      | Rev. 7        | XI    | The 8th, Venus' first appearance in the east in Aquarius                                     |
| 245            | 88             | 'Obv. 18'-19' | I     | Around until the 10th, Mars became stationary to the east                                    |
|                | LBAT **1179-80 | Obv. 2        | I     | [2]7th Mars 'stationary' in Sagittarius  |
| 245            | 88             | 'Obv. 19'     | II    | Around the 20th, Mars' acronychal rising.  |
|                | LBAT **1179-80 | Obv. 4        | II    | The 29th, Mars' acronychal rising.   |
| 245            | 88             | 'Obv. 8'      | III   | The 29th, Mercury's last appearance in the west in ...                                       |
|                | LBAT *1179-80  | Obv. 5-6      | III   | The 22nd, Mercury's last appearance [in x in] Cancer   |
| 245            | 88             | 'Obv. 19'-20' | III   | Until the 25th, Mars became stationary to the west   |
|                | LBAT **1179-80 | Obv. 7        | IV    | The 3rd, Mars stationary in the beginning of Sagittarius                                     |
| 245            | 88             | 'Obv. 16'     | IV    | Around until the 14th, Saturn became stationary to the east in Pisces                        |
|                | LBAT *1079-80  | Obv. 7        | IV    | The 7th, Saturn 'stationary' [in] P[isces]   |
| 245            | 88             | 'Obv. 9'      | IV    | (ideal) first appearance in the east on the 22nd   |
|                | LBAT *1179-80  | Obv. 8        | IV    | The 22nd, Mercury's first appearance in the east in Cancer                                   |
| 245            | 88             | 'Obv. 10'-11' | VII   | Around the 18 <sup>th</sup> , [Mercury's last appearance] in the west ... [omitted]          |
|                | LBAT *1179-80  | Obv. 13-14    | VII   | The 15th, Mercury's last appearance in the west, omitted                                     |
| 245            | 88             | 'Obv. 11'     | VIII  | The 8th, Mercury's [first appearance] in the east in ... (ideal) first appearance on the 5th |
|                | LBAT *1179-80  | Rev. 15-16    | VIII  | 'The 8th' [Mercury's] first appearance in the east in the end of Libra                       |

## Appendix G

| Goal year (SE) | Text no.   |         | Month          | Observation  |
|----------------|------------|---------|----------------|--|
| 246            | 91         | Obv.' 2 | I <sup>?</sup> | Around the 6th, Jupiter's first appearance in the end of Pisces  |
|                | LBAT *1181 | Obv. 1  | I              | The 4th, Jupiter's first appearance in Pisces  |
| 247            | 92         | Obv. 11 | I              | The 4th, Mer[cury's] first appearance [...] (ideal) first appearance on the 3rd <sup>?</sup>   |
|                | LBAT 1182  | Obv. 1  | I              | The 2nd, 'Mercury's' <sup>?</sup> 1 first appearance in the west in Taurus   |
| 247            | 92         | Obv. 14 | IV             | [The x]+1st, Mercury's last appearance in the east in the beginning of Gemini; from the 28th of Month III when I watched [I did not see it...] |
|                | LBAT 1182  | Obv. 6  | III            | 'The 25th' <sup>1</sup> , Mercury's last appearance in the east in Gemini  |

***Appendix H: an illustration of whether a month shift is necessary or not when using Goal-Year periods to make planetary predictions, for each month of the Metonic cycle***

| Month in observations year |              |                        |                        |                        |                        |                        |            | Metonic cycle          |                 |
|----------------------------|--------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------|------------------------|-----------------|
| Jupiter (71)               | Jupiter (83) | Venus (8)              | Mercury (46)           | Saturn (59)            | Mars (79)              | Mars (47)              | Moon (18)  | Goal year month        | year            |
| I                          | <b>XII</b>   | <b>XII<sub>2</sub></b> | <b>XII<sub>2</sub></b> | <b>XII<sub>2</sub></b> | I                      | I                      | <b>XII</b> | ...<br>predicts<br>... | I               |
| II                         | <b>I</b>     | <b>I</b>               | <b>I</b>               | <b>I</b>               | II                     | II                     | <b>I</b>   |                        | II              |
| III                        | <b>II</b>    | <b>II</b>              | <b>II</b>              | <b>II</b>              | III                    | III                    | <b>II</b>  |                        | III             |
| IV                         | <b>III</b>   | <b>III</b>             | <b>III</b>             | <b>III</b>             | IV                     | IV                     | <b>III</b> |                        | IV              |
| V                          | <b>IV</b>    | <b>IV</b>              | <b>IV</b>              | <b>IV</b>              | V                      | V                      | <b>IV</b>  |                        | V               |
| VI                         | <b>V</b>     | <b>V</b>               | <b>V</b>               | <b>V</b>               | VI                     | VI                     | <b>V</b>   |                        | VI              |
| <b>VII</b>                 | <b>VI</b>    | <b>VI</b>              | <b>VI</b>              | <b>VI</b>              | <b>VII</b>             | <b>VII</b>             | <b>VI</b>  |                        | VI <sub>2</sub> |
| <b>VIII</b>                | VII          | VII                    | VII                    | VII                    | <b>VIII</b>            | <b>VIII</b>            | VII        |                        | VII             |
| <b>IX</b>                  | VIII         | VIII                   | VIII                   | VIII                   | <b>IX</b>              | <b>IX</b>              | VIII       |                        | VIII            |
| <b>X</b>                   | IX           | IX                     | IX                     | IX                     | <b>X</b>               | <b>X</b>               | IX         |                        | IX              |
| <b>XI</b>                  | X            | X                      | X                      | X                      | <b>XI</b>              | <b>XI</b>              | X          |                        | X               |
| <b>XII</b>                 | XI           | XI                     | XI                     | XI                     | <b>XII</b>             | <b>XII</b>             | XI         |                        | XI              |
| <b>XII<sub>2</sub></b>     | XII          | XII                    | XII                    | XII                    | <b>XII<sub>2</sub></b> | <b>XII<sub>2</sub></b> | XII        |                        | XII             |
| I                          | I            | I                      | I                      | I                      | I                      | I                      | I          | ...<br>predicts<br>... | I               |
| II                         | II           | II                     | II                     | II                     | II                     | II                     | II         |                        | II              |
| III                        | III          | III                    | III                    | III                    | III                    | III                    | III        |                        | III             |
| IV                         | IV           | IV                     | IV                     | IV                     | IV                     | IV                     | IV         |                        | IV              |
| V                          | V            | V                      | V                      | V                      | V                      | V                      | V          |                        | V               |
| VI                         | VI           | VI                     | VI                     | VI                     | VI                     | VI                     | VI         |                        | VI              |
| VII                        | VII          | VII                    | VII                    | VII                    | VII                    | VII                    | VII        |                        | VII             |

| Month in observations year |                  |                  |                  |                 |           |           |                  | Metonic cycle          |                  |   |
|----------------------------|------------------|------------------|------------------|-----------------|-----------|-----------|------------------|------------------------|------------------|---|
| Jupiter (71)               | Jupiter (83)     | Venus (8)        | Mercury (46)     | Saturn (59)     | Mars (79) | Mars (47) | Moon (18)        | Goal year month        | year             |   |
| VIII                       | VIII             | VIII             | VIII             | VIII            | VIII      | VIII      | VIII             | VIII                   |                  |   |
| IX                         | IX               | IX               | IX               | IX              | IX        | IX        | IX               | IX                     |                  |   |
| X                          | X                | X                | X                | X               | X         | X         | X                | X                      |                  |   |
| XI                         | XI               | XI               | XI               | XI              | XI        | XI        | XI               | XI                     |                  |   |
| XII                        | XII              | XII              | XII              | XII             | XII       | XII       | XII              | XII                    |                  |   |
|                            |                  |                  |                  |                 |           |           |                  |                        |                  |   |
| I                          | XII <sub>2</sub> | I                | I                | I               | I         | I         | XII <sub>2</sub> | ...<br>predicts<br>... | I                | 3 |
| II                         | I                | II               | II               | II              | II        | II        | I                |                        | II               |   |
| III                        | II               | III              | III              | III             | III       | III       | II               |                        | III              |   |
| IV                         | III              | IV               | IV               | IV              | IV        | IV        | III              |                        | IV               |   |
| V                          | IV               | V                | V                | V               | V         | V         | IV               |                        | V                |   |
| VI                         | V                | VI               | VI               | VI              | VI        | VI        | V                |                        | VI               |   |
| VII                        | VI               | VII              | VII              | VI <sub>2</sub> | VII       | VII       | VI               |                        | VII              |   |
| VIII                       | VII              | VIII             | VIII             | VII             | VIII      | VIII      | VII              |                        | VIII             |   |
| IX                         | VIII             | IX               | IX               | VIII            | IX        | IX        | VIII             |                        | IX               |   |
| X                          | IX               | X                | X                | IX              | X         | X         | IX               |                        | X                |   |
| XI                         | X                | XI               | XI               | X               | XI        | XI        | X                |                        | XI               |   |
| XII                        | XI               | XII              | XII              | XI              | XII       | XII       | XI               |                        | XII              |   |
| I                          | XII              | XII <sub>2</sub> | XII <sub>2</sub> | XII             | I         | I         | XII              |                        | XII <sub>2</sub> |   |
|                            |                  |                  |                  |                 |           |           |                  |                        |                  |   |
| II                         | I                | I                | I                | I               | II        | II        | I                | ...<br>predicts<br>... | I                | 4 |
| III                        | II               | II               | II               | II              | III       | III       | II               |                        | II               |   |
| IV                         | III              | III              | III              | III             | IV        | IV        | III              |                        | III              |   |
| V                          | IV               | IV               | IV               | IV              | V         | V         | IV               |                        | IV               |   |

| Month in observations year |                        |           |              |                        |                       |                        |                        |                        | Metonic cycle |      |
|----------------------------|------------------------|-----------|--------------|------------------------|-----------------------|------------------------|------------------------|------------------------|---------------|------|
| Jupiter (71)               | Jupiter (83)           | Venus (8) | Mercury (46) | Saturn (59)            | Mars (79)             | Mars (47)              | Moon (18)              | Goal year month        | year          |      |
| <b>VI</b>                  | V                      | V         | V            | V                      | <b>VI</b>             | <b>VI</b>              | V                      | V                      |               |      |
| <b>VII</b>                 | VI                     | VI        | VI           | VI                     | <b>VI<sub>2</sub></b> | <b>VII</b>             | VI                     | VI                     |               |      |
| <b>VIII</b>                | VII                    | VII       | VII          | VII                    | VII                   | <b>VIII</b>            | VII                    | VII                    |               |      |
| <b>IX</b>                  | VIII                   | VIII      | VIII         | VIII                   | VIII                  | <b>IX</b>              | VIII                   | VIII                   |               |      |
| <b>X</b>                   | IX                     | IX        | IX           | IX                     | IX                    | <b>X</b>               | IX                     | IX                     |               |      |
| <b>XI</b>                  | X                      | X         | X            | X                      | X                     | <b>XI</b>              | X                      | X                      |               |      |
| <b>XII</b>                 | XI                     | XI        | XI           | XI                     | XI                    | <b>XII</b>             | XI                     | XI                     |               |      |
| <b>XII<sub>2</sub></b>     | XII                    | XII       | XII          | XII                    | XII                   | <b>XII<sub>2</sub></b> | XII                    | XII                    |               |      |
| I                          | I                      | I         | I            | I                      | I                     | I                      | I                      | ...<br>predicts<br>... | I             | 5    |
| II                         | II                     | II        | II           | II                     | II                    | II                     | II                     |                        | II            |      |
| III                        | III                    | III       | III          | III                    | III                   | III                    | III                    |                        | III           |      |
| IV                         | IV                     | IV        | IV           | IV                     | IV                    | IV                     | IV                     |                        |               | IV   |
| V                          | V                      | V         | V            | V                      | V                     | V                      | V                      |                        |               | V    |
| VI                         | VI                     | VI        | VI           | VI                     | VI                    | VI                     | VI                     |                        |               | VI   |
| VII                        | VII                    | VII       | VII          | VII                    | VII                   | VII                    | VII                    |                        |               | VII  |
| VIII                       | VIII                   | VIII      | VIII         | VIII                   | VIII                  | VIII                   | VIII                   |                        |               | VIII |
| IX                         | IX                     | IX        | IX           | IX                     | IX                    | IX                     | IX                     |                        |               | IX   |
| X                          | X                      | X         | X            | X                      | X                     | X                      | X                      |                        |               | X    |
| XI                         | XI                     | XI        | XI           | XI                     | XI                    | XI                     | XI                     |                        |               | XI   |
| XII                        | XII                    | XII       | XII          | XII                    | XII                   | XII                    | XII                    |                        |               | XII  |
| I                          | <b>XII<sub>2</sub></b> | I         | I            | <b>XII<sub>2</sub></b> | I                     | I                      | <b>XII<sub>2</sub></b> | ...<br>predicts        | I             | 6    |
| II                         | <b>I</b>               | II        | II           | <b>I</b>               | II                    | II                     | <b>I</b>               |                        | II            |      |

| Month in observations year |              |                  |                  |             |                  |                        |             |                        | Metonic cycle<br>year |
|----------------------------|--------------|------------------|------------------|-------------|------------------|------------------------|-------------|------------------------|-----------------------|
| Jupiter (71)               | Jupiter (83) | Venus (8)        | Mercury (46)     | Saturn (59) | Mars (79)        | Mars (47)              | Moon (18)   | Goal year month        |                       |
| III                        | <b>II</b>    | III              | III              | <b>II</b>   | III              | III                    | <b>II</b>   | ...                    | III                   |
| IV                         | <b>III</b>   | IV               | IV               | <b>III</b>  | IV               | IV                     | <b>III</b>  |                        | IV                    |
| V                          | <b>IV</b>    | V                | V                | <b>IV</b>   | V                | V                      | <b>IV</b>   |                        | V                     |
| VI                         | <b>V</b>     | VI               | VI               | <b>V</b>    | VI               | VI                     | <b>V</b>    |                        | VI                    |
| VII                        | <b>VI</b>    | VII              | VII              | <b>VI</b>   | VII              | VII                    | <b>VI</b>   |                        | VII                   |
| VIII                       | <b>VII</b>   | VIII             | VIII             | <b>VII</b>  | VIII             | VIII                   | <b>VII</b>  |                        | VIII                  |
| IX                         | <b>VIII</b>  | IX               | IX               | <b>VIII</b> | IX               | IX                     | <b>VIII</b> |                        | IX                    |
| X                          | <b>IX</b>    | X                | X                | <b>IX</b>   | X                | X                      | <b>IX</b>   |                        | X                     |
| XI                         | <b>X</b>     | XI               | XI               | <b>X</b>    | XI               | XI                     | <b>X</b>    |                        | XI                    |
| XII                        | <b>XI</b>    | XII              | XII              | <b>XI</b>   | XII              | XII                    | <b>XI</b>   |                        | XII                   |
| XII <sub>2</sub>           | <b>XII</b>   | XII <sub>2</sub> | XII <sub>2</sub> | <b>XII</b>  | XII <sub>2</sub> | <b>I</b>               | <b>XII</b>  |                        | XII <sub>2</sub>      |
| I                          | <b>I</b>     | <b>I</b>         | <b>I</b>         | <b>I</b>    | <b>I</b>         | <b>II</b>              | <b>I</b>    | ...<br>predicts<br>... | <b>I</b>              |
| II                         | <b>II</b>    | <b>II</b>        | <b>II</b>        | <b>II</b>   | <b>II</b>        | <b>III</b>             | <b>II</b>   |                        | <b>II</b>             |
| III                        | <b>III</b>   | <b>III</b>       | <b>III</b>       | <b>III</b>  | <b>III</b>       | <b>IV</b>              | <b>III</b>  |                        | <b>III</b>            |
| IV                         | <b>IV</b>    | <b>IV</b>        | <b>IV</b>        | <b>IV</b>   | <b>IV</b>        | <b>V</b>               | <b>IV</b>   |                        | <b>IV</b>             |
| V                          | <b>V</b>     | <b>V</b>         | <b>V</b>         | <b>V</b>    | <b>V</b>         | <b>VI</b>              | <b>V</b>    |                        | <b>V</b>              |
| VI                         | <b>VI</b>    | <b>VI</b>        | <b>VI</b>        | <b>VI</b>   | <b>VI</b>        | <b>VII</b>             | <b>VI</b>   |                        | <b>VI</b>             |
| VII                        | <b>VII</b>   | <b>VII</b>       | <b>VII</b>       | <b>VII</b>  | <b>VII</b>       | <b>VIII</b>            | <b>VII</b>  |                        | <b>VII</b>            |
| VIII                       | <b>VIII</b>  | <b>VIII</b>      | <b>VIII</b>      | <b>VIII</b> | <b>VIII</b>      | <b>IX</b>              | <b>VIII</b> |                        | <b>VIII</b>           |
| IX                         | <b>IX</b>    | <b>IX</b>        | <b>IX</b>        | <b>IX</b>   | <b>IX</b>        | <b>X</b>               | <b>IX</b>   |                        | <b>IX</b>             |
| X                          | <b>X</b>     | <b>X</b>         | <b>X</b>         | <b>X</b>    | <b>X</b>         | <b>XI</b>              | <b>X</b>    |                        | <b>X</b>              |
| XI                         | <b>XI</b>    | <b>XI</b>        | <b>XI</b>        | <b>XI</b>   | <b>XI</b>        | <b>XII</b>             | <b>XI</b>   |                        | <b>XI</b>             |
| XII                        | <b>XII</b>   | <b>XII</b>       | <b>XII</b>       | <b>XII</b>  | <b>XII</b>       | <b>XII<sub>2</sub></b> | <b>XII</b>  |                        | <b>XII</b>            |

Appendix H

| Month in observations year |                       |                       |                       |                        |           |           |                        |                        | Metonic cycle |
|----------------------------|-----------------------|-----------------------|-----------------------|------------------------|-----------|-----------|------------------------|------------------------|---------------|
| Jupiter (71)               | Jupiter (83)          | Venus (8)             | Mercury (46)          | Saturn (59)            | Mars (79) | Mars (47) | Moon (18)              | Goal year month        | year          |
| I                          | I                     | I                     | I                     | I                      | I         | I         | I                      | ...<br>predicts<br>... | I             |
| II                         | II                    | II                    | II                    | II                     | II        | II        | II                     |                        | II            |
| III                        | III                   | III                   | III                   | III                    | III       | III       | III                    |                        | III           |
| IV                         | IV                    | IV                    | IV                    | IV                     | IV        | IV        | IV                     |                        | IV            |
| V                          | V                     | V                     | V                     | V                      | V         | V         | V                      |                        | V             |
| VI                         | VI                    | VI                    | VI                    | VI                     | VI        | VI        | VI                     |                        | VI            |
| VII                        | <b>VI<sub>2</sub></b> | VII                   | VII                   | VII                    | VII       | VII       | VII                    |                        | VII           |
| VIII                       | <b>VII</b>            | VIII                  | VIII                  | VIII                   | VIII      | VIII      | VIII                   |                        | VIII          |
| IX                         | <b>VIII</b>           | IX                    | IX                    | IX                     | IX        | IX        | IX                     |                        | IX            |
| X                          | <b>IX</b>             | X                     | X                     | X                      | X         | X         | X                      |                        | X             |
| XI                         | <b>X</b>              | XI                    | XI                    | XI                     | XI        | XI        | XI                     |                        | XI            |
| XII                        | <b>XI</b>             | XII                   | XII                   | XII                    | XII       | XII       | XII                    |                        | XII           |
| I                          | <b>XII</b>            | I                     | I                     | <b>XII<sub>2</sub></b> | I         | I         | <b>XII<sub>2</sub></b> | ...<br>predicts<br>... | I             |
| II                         | <b>I</b>              | II                    | II                    | <b>I</b>               | II        | II        | <b>I</b>               |                        | II            |
| III                        | <b>II</b>             | III                   | III                   | <b>II</b>              | III       | III       | <b>II</b>              |                        | III           |
| IV                         | <b>III</b>            | IV                    | IV                    | <b>III</b>             | IV        | IV        | <b>III</b>             |                        | IV            |
| V                          | <b>IV</b>             | V                     | V                     | <b>IV</b>              | V         | V         | <b>IV</b>              |                        | V             |
| VI                         | <b>V</b>              | VI                    | VI                    | <b>V</b>               | VI        | VI        | <b>V</b>               |                        | VI            |
| VII                        | <b>VI</b>             | <b>VI<sub>2</sub></b> | <b>VI<sub>2</sub></b> | <b>VI</b>              | VII       | VII       | <b>VI</b>              |                        | VII           |
| VIII                       | <b>VII</b>            | <b>VII</b>            | <b>VII</b>            | <b>VII</b>             | VIII      | VIII      | <b>VII</b>             |                        | VIII          |
| IX                         | <b>VIII</b>           | <b>VIII</b>           | <b>VIII</b>           | <b>VIII</b>            | IX        | IX        | <b>VIII</b>            |                        | IX            |
| X                          | <b>IX</b>             | <b>IX</b>             | <b>IX</b>             | <b>IX</b>              | X         | X         | <b>IX</b>              |                        | X             |

| Month in observations year |                        |            |              |             |                  |                       |                        | Metonic cycle    |      |
|----------------------------|------------------------|------------|--------------|-------------|------------------|-----------------------|------------------------|------------------|------|
| Jupiter (71)               | Jupiter (83)           | Venus (8)  | Mercury (46) | Saturn (59) | Mars (79)        | Mars (47)             | Moon (18)              | Goal year month  | year |
| XI                         | <b>X</b>               | <b>X</b>   | <b>X</b>     | <b>X</b>    | XI               | XI                    | <b>X</b>               | XI               |      |
| XII                        | <b>XI</b>              | <b>XI</b>  | <b>XI</b>    | <b>XI</b>   | XII              | XII                   | <b>XI</b>              | XII              |      |
| XII <sub>2</sub>           | <b>XII</b>             | <b>XII</b> | <b>XII</b>   | <b>XII</b>  | XII <sub>2</sub> | <b>I</b>              | <b>XII</b>             | XII <sub>2</sub> |      |
| I                          | I                      | I          | I            | I           | I                | <b>II</b>             | I                      | ...              | I    |
| II                         | II                     | II         | II           | II          | II               | <b>III</b>            | II                     | predicts         | II   |
| III                        | III                    | III        | III          | III         | III              | <b>IV</b>             | III                    | ...              | III  |
| IV                         | IV                     | IV         | IV           | IV          | IV               | <b>V</b>              | IV                     |                  | IV   |
| V                          | V                      | V          | V            | V           | V                | <b>VI</b>             | V                      |                  | V    |
| VI                         | VI                     | VI         | VI           | VI          | VI               | <b>VI<sub>2</sub></b> | VI                     |                  | VI   |
| VII                        | VII                    | VII        | VII          | VII         | VII              | VII                   | VII                    |                  | VII  |
| VIII                       | VIII                   | VIII       | VIII         | VIII        | VIII             | VIII                  | VIII                   |                  | VIII |
| IX                         | IX                     | IX         | IX           | IX          | IX               | IX                    | IX                     |                  | IX   |
| X                          | X                      | X          | X            | X           | X                | X                     | X                      |                  | X    |
| XI                         | XI                     | XI         | XI           | XI          | XI               | XI                    | XI                     |                  | XI   |
| XII                        | XII                    | XII        | XII          | XII         | XII              | XII                   | XII                    |                  | XII  |
| I                          | <b>XII<sub>2</sub></b> | I          | I            | I           | I                | I                     | <b>XII<sub>2</sub></b> | ...              | I    |
| II                         | <b>I</b>               | II         | II           | II          | II               | II                    | <b>I</b>               | predicts         | II   |
| III                        | <b>II</b>              | III        | III          | III         | III              | III                   | <b>II</b>              | ...              | III  |
| IV                         | <b>III</b>             | IV         | IV           | IV          | IV               | IV                    | <b>III</b>             |                  | IV   |
| V                          | <b>IV</b>              | V          | V            | V           | V                | V                     | <b>IV</b>              |                  | V    |
| VI                         | <b>V</b>               | VI         | VI           | VI          | VI               | VI                    | <b>V</b>               |                  | VI   |
| VII                        | <b>VI</b>              | VII        | VII          | VII         | VII              | VII                   | <b>VI</b>              |                  | VII  |

Appendix H



| Month in observations year |              |                  |                  |                  |                  |                  |           |                  | Metonic cycle |    |
|----------------------------|--------------|------------------|------------------|------------------|------------------|------------------|-----------|------------------|---------------|----|
| Jupiter (71)               | Jupiter (83) | Venus (8)        | Mercury (46)     | Saturn (59)      | Mars (79)        | Mars (47)        | Moon (18) | Goal year month  | year          |    |
| VIII                       | VII          | VIII             | VIII             | VIII             | VIII             | VIII             | VII       | VIII             |               |    |
| IX                         | VIII         | IX               | IX               | IX               | IX               | IX               | VIII      | IX               |               |    |
| X                          | IX           | X                | X                | X                | X                | X                | IX        | X                |               |    |
| XI                         | X            | XI               | XI               | XI               | XI               | XI               | X         | XI               |               |    |
| XII                        | XI           | XII              | XII              | XII              | XII              | XII              | XI        | XII              |               |    |
| I                          | XII          | XII <sub>2</sub> | XII <sub>2</sub> | XII <sub>2</sub> | I                | I                | XII       | XII <sub>2</sub> |               |    |
|                            |              |                  |                  |                  |                  |                  |           |                  |               |    |
| II                         | I            | I                | I                | I                | II               | II               | I         | ...              | I             | 12 |
| III                        | II           | II               | II               | II               | III              | III              | II        | predicts         | II            |    |
|                            |              |                  |                  |                  |                  |                  |           | ...              |               |    |
| IV                         | III          | III              | III              | III              | IV               | IV               | III       |                  | III           |    |
| V                          | IV           | IV               | IV               | IV               | V                | V                | IV        |                  | IV            |    |
| VI                         | V            | V                | V                | V                | VI               | VI               | V         |                  | V             |    |
| VII                        | VI           | VI               | VI               | VI               | VII              | VII              | VI        |                  | VI            |    |
| VIII                       | VII          | VII              | VII              | VII              | VIII             | VIII             | VII       |                  | VII           |    |
| IX                         | VIII         | VIII             | VIII             | VIII             | IX               | IX               | VIII      |                  | VIII          |    |
| X                          | IX           | IX               | IX               | IX               | X                | X                | IX        |                  | IX            |    |
| XI                         | X            | X                | X                | X                | XI               | XI               | X         |                  | X             |    |
| XII                        | XI           | XI               | XI               | XI               | XII              | XII              | XI        |                  | XI            |    |
| XII <sub>2</sub>           | XII          | XII              | XII              | XII              | XII <sub>2</sub> | XII <sub>2</sub> | XII       |                  | XII           |    |
|                            |              |                  |                  |                  |                  |                  |           |                  |               |    |
| I                          | I            | I                | I                | I                | I                | I                | I         | ...              | I             | 13 |
| II                         | II           | II               | II               | II               | II               | II               | II        | predicts         | II            |    |
|                            |              |                  |                  |                  |                  |                  |           | ...              |               |    |
| III                        | III          | III              | III              | III              | III              | III              | III       |                  | III           |    |
| IV                         | IV           | IV               | IV               | IV               | IV               | IV               | IV        |                  | IV            |    |

| Month in observations year |                  |                  |                  |                  |                  |           |                  |                        | Metonic cycle    |    |
|----------------------------|------------------|------------------|------------------|------------------|------------------|-----------|------------------|------------------------|------------------|----|
| Jupiter (71)               | Jupiter (83)     | Venus (8)        | Mercury (46)     | Saturn (59)      | Mars (79)        | Mars (47) | Moon (18)        | Goal year month        | year             |    |
| V                          | V                | V                | V                | V                | V                | V         | V                | V                      |                  |    |
| VI                         | VI               | VI               | VI               | VI               | VI               | VI        | VI               | VI                     |                  |    |
| VII                        | VII              | VII              | VII              | VII              | VII              | VII       | VII              | VII                    |                  |    |
| VIII                       | VIII             | VIII             | VIII             | VIII             | VIII             | VIII      | VIII             | VIII                   |                  |    |
| IX                         | IX               | IX               | IX               | IX               | IX               | IX        | IX               | IX                     |                  |    |
| X                          | X                | X                | X                | X                | X                | X         | X                | X                      |                  |    |
| XI                         | XI               | XI               | XI               | XI               | XI               | XI        | XI               | XI                     |                  |    |
| XII                        | XII              | XII              | XII              | XII              | XII              | XII       | XII              | XII                    |                  |    |
|                            |                  |                  |                  |                  |                  |           |                  |                        |                  |    |
| I                          | XII <sub>2</sub> | I                | I                | XII <sub>2</sub> | I                | I         | XII <sub>2</sub> | ...<br>predicts<br>... | I                | 14 |
| II                         | I                | II               | II               | I                | II               | II        | I                |                        | II               |    |
| III                        | II               | III              | III              | II               | III              | III       | II               |                        | III              |    |
| IV                         | III              | IV               | IV               | III              | IV               | IV        | III              |                        | IV               |    |
| V                          | IV               | V                | V                | IV               | V                | V         | IV               |                        | V                |    |
| VI                         | V                | VI               | VI               | V                | VI               | VI        | V                |                        | VI               |    |
| VII                        | VI               | VII              | VII              | VI               | VII              | VII       | VI               |                        | VII              |    |
| VIII                       | VII              | VIII             | VIII             | VII              | VIII             | VIII      | VII              |                        | VIII             |    |
| IX                         | VIII             | IX               | IX               | VIII             | IX               | IX        | VIII             |                        | IX               |    |
| X                          | IX               | X                | X                | IX               | X                | X         | IX               |                        | X                |    |
| XI                         | X                | XI               | XI               | X                | XI               | XI        | X                |                        | XI               |    |
| XII                        | XI               | XII              | XII              | XI               | XII              | XII       | XI               |                        | XII              |    |
| I                          | XII              | XII <sub>2</sub> | XII <sub>2</sub> | XII              | XII <sub>2</sub> | I         | XII              |                        | XII <sub>2</sub> |    |
|                            |                  |                  |                  |                  |                  |           |                  |                        |                  |    |
| II                         | I                | I                | I                | I                | I                | II        | I                | ...                    | I                | 15 |

| Month in observations year |              |           |              |             |           |                        |           |                 | Metonic cycle |    |
|----------------------------|--------------|-----------|--------------|-------------|-----------|------------------------|-----------|-----------------|---------------|----|
| Jupiter (71)               | Jupiter (83) | Venus (8) | Mercury (46) | Saturn (59) | Mars (79) | Mars (47)              | Moon (18) | Goal year month | year          |    |
| <b>III</b>                 | II           | II        | II           | II          | II        | <b>III</b>             | II        | predicts        | II            |    |
|                            |              |           |              |             |           |                        |           | ...             |               |    |
| <b>IV</b>                  | III          | III       | III          | III         | III       | <b>IV</b>              | III       |                 | III           |    |
| <b>V</b>                   | IV           | IV        | IV           | IV          | IV        | <b>V</b>               | IV        |                 | IV            |    |
| <b>VI</b>                  | V            | V         | V            | V           | V         | <b>VI</b>              | V         |                 | V             |    |
| <b>VI<sub>2</sub></b>      | VI           | VI        | VI           | VI          | VI        | <b>VII</b>             | VI        |                 | VI            |    |
| VII                        | VII          | VII       | VII          | VII         | VII       | <b>VIII</b>            | VII       |                 | VII           |    |
| VIII                       | VIII         | VIII      | VIII         | VIII        | VIII      | <b>IX</b>              | VIII      |                 | VIII          |    |
| IX                         | IX           | IX        | IX           | IX          | IX        | <b>X</b>               | IX        |                 | IX            |    |
| X                          | X            | X         | X            | X           | X         | <b>XI</b>              | X         |                 | X             |    |
| XI                         | XI           | XI        | XI           | XI          | XI        | <b>XII</b>             | XI        |                 | XI            |    |
| XII                        | XII          | XII       | XII          | XII         | XII       | <b>XII<sub>2</sub></b> | XII       |                 | XII           |    |
| I                          | I            | I         | I            | I           | I         | I                      | I         | ...             | I             | 16 |
| II                         | II           | II        | II           | II          | II        | II                     | II        | predicts        | II            |    |
|                            |              |           |              |             |           |                        |           | ...             |               |    |
| III                        | III          | III       | III          | III         | III       | III                    | III       |                 | III           |    |
| IV                         | IV           | IV        | IV           | IV          | IV        | IV                     | IV        |                 | IV            |    |
| V                          | V            | V         | V            | V           | V         | V                      | V         |                 | V             |    |
| VI                         | VI           | VI        | VI           | VI          | VI        | VI                     | VI        |                 | VI            |    |
| VII                        | VII          | VII       | VII          | VII         | VII       | VII                    | VII       |                 | VII           |    |
| VIII                       | VIII         | VIII      | VIII         | VIII        | VIII      | VIII                   | VIII      |                 | VIII          |    |
| IX                         | IX           | IX        | IX           | IX          | IX        | IX                     | IX        |                 | IX            |    |
| X                          | X            | X         | X            | X           | X         | X                      | X         |                 | X             |    |
| XI                         | XI           | XI        | XI           | XI          | XI        | XI                     | XI        |                 | XI            |    |
| XII                        | XII          | XII       | XII          | XII         | XII       | XII                    | XII       |                 | XII           |    |

| Month in observations year |                  |                  |                  |                  |                  |           |                  |                        | Metonic cycle |    |
|----------------------------|------------------|------------------|------------------|------------------|------------------|-----------|------------------|------------------------|---------------|----|
| Jupiter (71)               | Jupiter (83)     | Venus (8)        | Mercury (46)     | Saturn (59)      | Mars (79)        | Mars (47) | Moon (18)        | Goal year month        | year          |    |
| I                          | XII <sub>2</sub> | I                | I                | XII <sub>2</sub> | I                | I         | XII <sub>2</sub> | ...<br>predicts<br>... | I             | 17 |
| II                         | I                | II               | II               | I                | II               | II        | I                |                        | II            |    |
| III                        | II               | III              | III              | II               | III              | III       | II               |                        | III           |    |
| IV                         | III              | IV               | IV               | III              | IV               | IV        | III              |                        | IV            |    |
| V                          | IV               | V                | V                | IV               | V                | V         | IV               |                        | V             |    |
| VI                         | V                | VI               | VI               | V                | VI               | VI        | V                |                        | VI            |    |
| VII                        | VI               | VII              | VII              | VI               | VII              | VII       | VI               |                        | VII           |    |
| VIII                       | VII              | VIII             | VIII             | VII              | VIII             | VIII      | VII              |                        | VIII          |    |
| IX                         | VIII             | IX               | IX               | VIII             | IX               | IX        | VIII             |                        | IX            |    |
| X                          | IX               | X                | X                | IX               | X                | X         | IX               |                        | X             |    |
| XI                         | X                | XI               | XI               | X                | XI               | XI        | X                |                        | XI            |    |
| XII                        | XI               | XII              | XII              | XI               | XII              | XII       | XI               |                        | XII           |    |
| XII <sub>2</sub>           | XII              | XII <sub>2</sub> | XII <sub>2</sub> | XII              | XII <sub>2</sub> | I         | XII              | XII <sub>2</sub>       |               |    |
| I                          | I                | I                | I                | I                | I                | II        | I                | ...<br>predicts<br>... | I             | 18 |
| II                         | II               | II               | II               | II               | II               | III       | II               |                        | II            |    |
| III                        | III              | III              | III              | III              | III              | IV        | III              |                        | III           |    |
| IV                         | IV               | IV               | IV               | IV               | IV               | V         | IV               |                        | IV            |    |
| V                          | V                | V                | V                | V                | V                | VI        | V                |                        | V             |    |
| VI                         | VI               | VI               | VI               | VI               | VI               | VII       | VI               |                        | VI            |    |
| VII                        | VII              | VII              | VII              | VII              | VII              | VIII      | VII              |                        | VII           |    |
| VIII                       | VIII             | VIII             | VIII             | VIII             | VIII             | IX        | VIII             |                        | VIII          |    |
| IX                         | IX               | IX               | IX               | IX               | IX               | X         | IX               |                        | IX            |    |

| Month in observations year |                        |           |              |             |           |                        |                       | Metonic cycle          |      |
|----------------------------|------------------------|-----------|--------------|-------------|-----------|------------------------|-----------------------|------------------------|------|
| Jupiter (71)               | Jupiter (83)           | Venus (8) | Mercury (46) | Saturn (59) | Mars (79) | Mars (47)              | Moon (18)             | Goal year month        | year |
| X                          | X                      | X         | X            | X           | X         | <b>XI</b>              | X                     | X                      |      |
| XI                         | XI                     | XI        | XI           | XI          | XI        | <b>XII</b>             | XI                    | XI                     |      |
| XII                        | XII                    | XII       | XII          | XII         | XII       | <b>XII<sub>2</sub></b> | XII                   | XII                    |      |
| I                          | <b>XII<sub>2</sub></b> | I         | I            | I           | I         | I                      | I                     | ...<br>predicts<br>... | I    |
| II                         | <b>I</b>               | II        | II           | II          | II        | II                     | II                    |                        | II   |
| III                        | <b>II</b>              | III       | III          | III         | III       | III                    | III                   |                        | III  |
| IV                         | <b>III</b>             | IV        | IV           | IV          | IV        | IV                     | IV                    |                        | IV   |
| V                          | <b>IV</b>              | V         | V            | V           | V         | V                      | V                     |                        | V    |
| VI                         | <b>V</b>               | VI        | VI           | VI          | VI        | VI                     | VI                    |                        | VI   |
| VII                        | <b>VI</b>              | VII       | VII          | VII         | VII       | VII                    | <b>VI<sub>2</sub></b> |                        | VII  |
| VIII                       | <b>VII</b>             | VIII      | VIII         | VIII        | VIII      | VIII                   | <b>VII</b>            |                        | VIII |
| IX                         | <b>VIII</b>            | IX        | IX           | IX          | IX        | IX                     | <b>VIII</b>           |                        | IX   |
| X                          | <b>IX</b>              | X         | X            | X           | X         | X                      | <b>IX</b>             |                        | X    |
| XI                         | <b>X</b>               | XI        | XI           | XI          | XI        | XI                     | <b>X</b>              |                        | XI   |
| XII                        | <b>XI</b>              | XII       | XII          | XII         | XII       | XII                    | <b>XI</b>             |                        | XII  |

***Appendix I: a comparison of records in the Goal-Year Texts with records in the non-mathematical predictive texts, to determine when a “month shift” is applied to the date of records when making predictions***

|                                  | Year<br>(SE) | Text         |           |                         |  | Month shift-<br>Seen <sup>2</sup> | Expected <sup>2</sup> |
|----------------------------------|--------------|--------------|-----------|-------------------------|--|-----------------------------------|-----------------------|
| Jupiter's Greek-letter phenomena |              |              |           |                         |  |                                   |                       |
| Diary                            | 34           | -277 A       | Rev. 19   | <b>VI</b>               | The 20th, Jupiter became stationary in Gemini                                  |                                   |                       |
| NSA                              | 105          | BM 132283    | Obv. 20   | <b>V</b>                | The 20th, Jupiter in the end of Taurus [...]                                   | y                                 | y                     |
| GYT                              | 36           | 17           | 'Obv.' 1' | <b>X</b>                | The 20th, Jupiter's acronychal rising  |                                   |                       |
| NSA                              | 107          | LBAT 1016-18 | Rev. 3    | <b>[X<sup>2</sup>]</b>  | The 20th, Jupiter's acronychal rising  | n                                 | n                     |
| Diary                            | 58           | -253 A1      | Obv.' 1   | <b>[VII]</b>            | The 1st, Jupiter became stationary in Gemini                                   |                                   |                       |
| Alm                              | 129          | LBAT 1123    | Obv. 12   | <b>[VII]</b>            | The 1st, Jupiter stationary in Gemini  | n                                 | n                     |
| GYT                              | 58           | 27           | Obv. 3    | <b>[XI]</b>             | Around the 4th, when Jupiter became stationary to the west...                  |                                   |                       |
| Alm                              | 129          | LBAT 1123    | Rev. 1    | <b>XI</b>               | [1st-12th Jup]iter stationary in Taurus  | n                                 | n                     |
| Diary                            | 66           | -245 B       | Rev.' 3   | <b>IV</b>               | The 8th, Jupiter's acronychal rising   |                                   |                       |
| NSA                              | 137          | LBAT 1027-8  | Obv. 5    | <b>[IV<sup>2</sup>]</b> | [8th-13th] Jupiter's acronychal rising   | n                                 | n                     |
| Diary                            | 79           | -232         | Obv. 5    | <b>VII</b>              | Around the 14th Jupiter became stationary to the west in the e[nd of Aquarius] |                                   |                       |
| NSA                              | 150          | LBAT *1030   | Rev. 1    | <b>VII</b>              | The 14th, Jupiter stationary in the end of Aquarius                            | n                                 | n                     |
| Diary                            | 79           | -232         | Rev. 24   | <b>XI</b>               | Around the 27th, Jupiter's last appearance in Pisces                           |                                   |                       |
| NSA                              | 150          | LBAT *1030   | Rev. 18   | <b>XI</b>               | The 24th/29th, first part Jupiter in the west [in x last appearance]           | n                                 | n                     |
| Diary                            | 114          | -197 C1      | Rev.' 3-4 | <b>X</b>                | The 28th, Jupiter's last appearance in Aquarius                                |                                   |                       |
| Alm                              | 185          | LBAT 1139    | Obv. 7    | <b>[X]</b>              | 'x' Jupiter in Aquarius 'x'  | n                                 | n                     |

|              | Year<br>(SE) | Text                   |                       |  |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|--------------|--------------|------------------------|-----------------------|--|--|---|
| Diary<br>NSA | 118<br>189   | -193 A<br>LBAT' **1055 | 'Rev. 3'<br>Obv. 12   | <b>II</b><br><b>II</b>                 | 25th, Jupiter's last appearance in Gemini<br>The 25th, Jupiter's last appearance in Gemini                                     | n n   |
| Diary<br>NSA | 118<br>189   | -193 B<br>LBAT' **1055 | 'Obv.' 10'<br>Rev. 44 | <b>VII</b><br><b>VI<sub>2</sub></b>    | Around the 26th, when Jupiter became stationary to the west [...]<br>The 26th, Jupiter stationary in the end of Gemini.        | y y   |
| Diary<br>NSA | 118<br>189   | -193 D<br>LBAT' **1055 | 'Rev.' 15'<br>Rev. 58 | <b>XI<sup>?</sup></b><br><b>X</b>      | [Around <sup>?</sup> ] the 24th [when] Jupiter [became stationary] to the west [...]<br>The 24th, Jupiter stationary in Gemini | y y   |
| GYT<br>NSA   | 123<br>194   | 69<br>LBAT' 1057       | Obv. 1<br>Obv. 2      | <b>I</b><br><b>I</b>                   | Around the 15th, Jupiter's acronychal [rising ...]<br>The 16th, Jupiter's acronychal [rising ...]                              | n n   |
| GYT<br>NSA   | 123<br>194   | 69<br>LBAT' 1057       | Obv. 1-2<br>Obv. 14   | <b>[III<sup>?</sup>]</b><br><b>III</b> | The 19th, Jupiter became stationary to the west, [nn] cubits behind $\beta$ Librae<br>The 19th, Jupiter stationary in Libra.   | n n   |
| GYT<br>NSA   | 130<br>201   | 73<br>LBAT' **1059     | Obv. 1<br>Obv. 10     | <b>[II]</b><br><b>II</b>               | The xth, Jupiter's last appearance in Gemini<br>The 13th, Jupiter's last appearance in Gemini                                  | n n   |
| GYT<br>NSA   | 130<br>201   | 73<br>LBAT' **1059     | Obv. 1<br>Obv. 15     | <b>[III]</b><br><b>III</b>             | The 13th, Jupiter's first appearance in Gemini<br>The 12th, Jupiter's first appearance in Gemini.                              | n n   |
| GYT<br>NSA   | 130<br>201   | 73<br>LBAT' **1059     | Obv. 2<br>Rev. 37     | <b>[VII]</b><br><b>VII</b>             | [... when Jupiter became stationary to the east ...] 8 fingers above $\theta$ Cancr<br>The 11th, Jupiter stationary in Cancer  | n n   |
| GYT<br>NSA   | 130<br>201   | 73<br>LBAT' **1059     | Obv. 3<br>Rev. 49     | <b>[IX]</b><br><b>IX</b>               | [The xth, Jupiter's acronychal rising]<br>The 11th, Jupiter's acronychal rising  | n n   |

|              | Year<br>(SE) | Text                    |                     |                                    |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|--------------|--------------|-------------------------|---------------------|------------------------------------|---|---|
| GYT<br>NSA   | 130<br>201   | 73<br>LBAT **1059       | Obv. 3<br>Rev. 60   | <b>[XI]</b><br><b>XI</b>           | [... when Jupiter] became stationary [to the west] ... 3 cubits below $\beta$ Geminorum<br>The 11th, Jupiter stationary in Gemini             | n n   |
| GYT<br>Alm   | 130<br>201   | 73<br>LBAT 1151         | Obv. 1<br>Obv. 7    | <b>[III]</b><br><b>III</b>         | The 13th, Jupiter's first appearance in Gemini<br>The 12th, Jupiter's first appearance in Gemini.   | n n   |
| Diary<br>Alm | 138<br>209   | -173 A<br>LBAT 1153     | 'Rev. 9'<br>Rev. 9  | <b>XII</b><br><b>XII</b>           | The 12th, Jupiter's first appearance in Pisces ... (ideal) first on the 11th<br>The 10th, Jupiter's first appearance in Pisces                | n n   |
| Diary<br>Alm | 155<br>226   | -156 C<br>LBAT 1159     | Line 19'<br>Obv. 8  | <b>XII</b><br><b>XII</b>           | Until the 30th, when Jupiter became stationary to the west ...<br>[23-28th...] Jupiter stationary in Leo                                      | n n   |
| GYT<br>Alm   | 165<br>236   | 86<br>LBAT 1174         | Obv. 2<br>Obv. 4    | <b>[II]</b><br><b>II</b>           | [...] first appearance [...] (ideal) first appearance on the 19th<br>The 20th, Jupiter's first appearance in the end of 'Taurus' <sup>1</sup> | n n   |
| Diary<br>Alm | 165<br>236   | -146<br>LBAT 1174       | Rev.' 3<br>Rev. 6   | <b>X</b><br><b>X</b>               | [18-20th] when Jupiter became stationary to the west ... 6 fingers in front of $\mu$ Geminorum<br>The 19th, Jupiter stationary in Gemini      | n n   |
| Diary<br>Alm | 174<br>245   | -137 E<br>LBAT *1179-80 | 'Rev. 5'<br>Rev. 22 | <b>XII</b><br><b>XI</b>            | [...] Jupiter's last appearance in Pisces<br>The 25th, Jupiter's last appearance in Pisces  | y <sup>2</sup> n  |
| GYT<br>Alm   | 175<br>246   | 91<br>LBAT *1181        | Obv.' 2<br>Obv. 1   | <b>I<sup>?</sup></b><br><b>I</b>   | Around the 6th, Jupiter's first appearance in the end of Pisces<br>The 4th, Jupiter's first appearance in Pisces.                             | n n   |
| GYT<br>Alm   | 176<br>247   | 92<br>LBAT 1182         | Obv. 1<br>Obv. 2    | <b>[I<sup>?</sup>]</b><br><b>I</b> | Around the 20+xth, Jupiter's [... first appearance <sup>?</sup> ]<br>The 22nd, Jupiter's first appearance in Aries                            | n n   |



|                                | Year<br>(SE) | Text         |             |               |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|--------------------------------|--------------|--------------|-------------|---------------|---|---|
| Diary                          | 234          | -77 A        | Rev.' 12-13 | <b>IV</b>     | Around the 23rd, when Jupiter became stationary to the east ... 1 cubit 8 fingers behind $\eta$ Piscium |   |
| Alm                            | 305          | LBAT 1195    | Obv. 8      | <b>[IV]</b>   | The 22nd, Jupiter stationary in the end of Pisces   | n n   |
| Diary                          | 234          | -77 A        | Rev.' 39    | <b>VI</b>     | Around the 21st, Jupiter's acronychal rising.   |   |
| Alm                            | 305          | LBAT 1195    | Obv. 11-12  | <b>[VI]</b>   | The 21st, Jupiter's acronychal rising   | n n   |
| Diary                          | 234          | -77 B        | 'Obv.' 20'  | <b>VIII</b>   | Until the 20th, when Jupiter became stationary to the west ...  |   |
| Alm                            | 305          | LBAT 1195    | Obv. 17     | <b>[VIII]</b> | [19th or 20th...] Jupiter stationary in Pisces  | n n   |
| Jupiter's Normal Star passages |              |              |             |               |   |   |
| GYT                            | 92           | 54           | Obv.' 7     | <b>VI</b>     | Night of the 12th last part Jupiter ... 4 cubits below $\alpha$ Arietis                                 |   |
| NSA                            | 175          | LBAT 1041-2  | Obv. 15     | <b>VI</b>     | [...] 'x' Jupiter 4 'x' below $\alpha$ Arietis  | n n   |
| GYT                            | 111          | 69           | Obv. 7      | <b>IX</b>     | Night of the 24th last [part Jupiter] 1 cubit [above $\theta$ ] Ophiuchi                                |   |
| NSA                            | 194          | LBAT 1057    | Rev. 6      | <b>X</b>      | Night of the 17th last part Jupiter 'x' cubits above $\theta$ [Ophiuchi?]                               | y y   |
| Venus' events                  |              |              |             |               |   |   |
| Diary                          | 62           | -249 B       | 'Rev.' 4'   | <b>XI</b>     | Night of the 4th last part Venus ... below $\beta$ Capricorni   |   |
| NSA                            | 70           | MM 86.11.369 | Rev. 7'     | <b>XI</b>     | [1st-4th] first part Venus 1 cubit 4 fingers below $\beta$ Capricorni                                   | n n   |
| Diary                          | 74           | -237         | 'Obv. 10'   | <b>III</b>    | [Night of the 2]7th last part Venus 1 finger above $\eta$ Geminorum                                     |   |
| NSA                            | 82           | MLC 1860     | Obv. 15     | <b>III</b>    | 25 last part Venus [...] above $\eta$ [Geminorum?]  | n n   |
| Diary                          | 74           | -237         | 'Obv. 10'   | <b>III</b>    | Night of the 29th last part Venus 1 finger above $\mu$ Geminorum  |   |
| NSA                            | 82           | MLC 1860     | Obv. 16     | <b>III</b>    | 27th last part Venus 'x' above $\mu$ Geminorum?   | n n   |

|       | Year<br>(SE) | Text        |            |             |  | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------|--------------|-------------|------------|-------------|--|---|
| Diary | 74           | -237        | Rev.' 12   | <b>V</b>    | Night of the 21st ... last part Venus 4 [fingers] above $\varrho$ Leonis                 |   |
| NSA   | 82           | MLC 1860    | Obv. 26    | <b>V</b>    | 18th last part Venus [...] above $\varrho$ [Leo]nis                                      | n n   |
| Diary | 85           | -226 A      | 'Obv. 6'   | <b>II</b>   | [3rd or 4th] [last part Venus] 5 cubits [below $\beta$ ] Arietis                         |   |
| NSA   | 93           | LBAT 1006   | Obv. 5     | <b>II</b>   | Night of the 2nd 'last part' Venus [...] below $\beta$ [Arietis]                         | n n   |
| Diary | 85           | -226 A      | Rev.' 14   | <b>III</b>  | Night of the 30th last part Venus 3 cubits below $\beta$ Tauri                           |   |
| NSA   | 93           | LBAT 1006   | Obv. 16    | <b>IV</b>   | Night of the 1st last part Venus [...] below [ $\beta/\zeta$ ] Tauri <sup>2</sup>        | n n   |
| GYT   | 88           | 10          | Obv.' 8    | <b>[I]</b>  | Night of the 17th first part Venus 4 1/2 cubits above $\gamma$ Geminorum                 |   |
| NSA   | 96           | LBAT **1007 | Obv. 3     | <b>I</b>    | Night of the 16th first part Venus <sup>2</sup> 4 [cubits x...] above $\gamma$ Geminorum | n n   |
| GYT   | 88           | 10          | Obv.' 9    | <b>III</b>  | The 3rd, Venus' last appearance in the west in Gemini                                    |   |
| NSA   | 96           | LBAT **1007 | Obv. 8     | <b>II</b>   | The 29th, Venus' 'last appearance' <sup>21</sup> in the west in Gemini                   | n n   |
| GYT   | 88           | 10          | Obv.' 11   | <b>IV</b>   | Night of the 10+[xth last part] Venus 1 1/2 cubits [...] $\mu$ Geminorum                 |   |
| NSA   | 96           | LBAT **1007 | Obv. 12    | <b>IV</b>   | Night of the 11th last part Venus 1 1/2 cubits below $\mu$ Geminorum.                    | n n   |
| GYT   | 88           | 10          | Obv.' 12   | <b>[V]</b>  | [...] last part of the night Venus 5 1/2 cubits below $\alpha$ Geminorum                 |   |
| NSA   | 96           | LBAT 1008   | Obv. 7     | <b>V</b>    | Night of the 1st last part Venus 5 1/2 cubits below $\alpha$ Geminorum.                  | n n   |
| GYT   | 88           | 10          | Obv.' 15   | <b>[VI]</b> | Night of the 30th last part Venus 4 cubits below $\theta$ Leonis                         |   |
| NSA   | 96           | LBAT 1008   | Obv. 15-16 | <b>VI</b>   | Night of the 29th last part Venus [...] 4 cubits   | n n   |
| GYT   | 88           | 10          | Obv.' 18   | <b>IX</b>   | Night of the 4th last part Venus 2 fingers above $\beta$ Scorpii                         |   |
| NSA   | 96           | LBAT 1008   | Rev. 7     | <b>IX</b>   | Night of the 2nd last part Venus 2 'fingers' above $\beta$ Scorpii                       | n n   |

|     | Year<br>(SE) | Text         |                |              |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-----|--------------|--------------|----------------|--------------|---|---|
| GYT | 88           | 10           | Obv.' 19       | <b>IX</b>    | [...] Venus 2 cubits above $\alpha$ Scorpii   |   |
| NSA | 96           | LBAT 1008    | Rev. 8         | <b>IX</b>    | [...] 'last part Venus' 3 cubits above $\alpha$ Scorpii.  | n n   |
| GYT | 88           | 10           | Obv.' 19       | <b>IX</b>    | Night of the 21st last part Venus 1 cubit 4 fingers above $\theta$ Ophiuchi                       |   |
| NSA | 96           | LBAT 1008    | Rev. 9         | <b>IX</b>    | Night of the '19th Venus' 1 cubit 4 fingers above $\theta$ Ophiuchi.                              | n n   |
| GYT | 88           | 10           | Obv.' 20       | <b>[X]</b>   | [...] Venus 2 $\frac{1}{2}$ cubits below $\beta$ Capricorni; I watched, but I did not see $\beta$ |   |
| NSA | 96           | LBAT 1008    | Rev. 15        | <b>X</b>     | Night of the '23rd' last part Venus 1 $\frac{1}{3}$ cubits below $\beta$ Capricorni               | n n   |
| GYT | 98           | 15           | Obv. 13        | <b>[V]</b>   | Night of the 10th last part Venus 3 fingers above $\alpha$ Leonis                                 |   |
| NSA | 106          | BM 41022+    | Obv. 8         | <b>V</b>     | Night of the 8th last part Venus 3 fingers above $\alpha$ Leonis.                                 | n n   |
| GYT | 98           | 15           | Obv. 16        | <b>[XII]</b> | [... Venus] 3 cubits [above $\alpha$ Tau]ri   |   |
| NSA | 106          | LBAT 1015    | Rev. 6         | <b>XII</b>   | [...] first part Venus 3 cubits above $\alpha$ Tauri  | n n   |
| GYT | 99           | 16           | 'Obv.' 11'     | <b>[II]</b>  | Night of the 22nd first part Venus [...] below $\delta$ Cancr                                     |   |
| NSA | 107          | LBAT 1016-18 | Obv. 5-6       | <b>II</b>    | Night of the 19th first part Venus [...] above [ $\gamma/\delta$ ] Cancr <sup>2</sup>             | n n   |
| GYT | 99           | 16           | 'Obv.' 12'-13' | <b>IV</b>    | Night of the 7th first part Venus 5 <sup>2</sup> cubits below $\theta$ Leonis                     |   |
| NSA | 107          | LBAT 1016-18 | Obv. 15        | <b>IV</b>    | 'Night of the' 6th first part Venus 4 cubits below $\theta$ Leonis.                               | n n   |
| GYT | 99           | 16           | 'Obv.' 17'-18' | <b>XI</b>    | Night of the 11th [last part Venus] $\frac{1}{2}$ cubit below $\beta$ Capricorni                  |   |
| NSA | 107          | LBAT 1016-18 | Rev. 5         | <b>XI</b>    | Night of the 9th [...] 'x' 1 Venus 2 cubits below $\beta$ [Cap]ricorni.                           | n n   |
| GYT | 99           | 16           | 'Obv.' 18'     | <b>XI</b>    | Night of the 25th last part Venus 1 cubit 8 fingers above $\gamma$ Capricorni                     |   |
| NSA | 107          | LBAT 1016-18 | Rev. 6         | <b>XI</b>    | Night of the 22nd las[t part] Venus 1 cubit 8 fingers 'x' $\gamma$ Capricorni.                    | n n   |

## Appendix I

|              | Year<br>(SE) | Text                  |                          |                            |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|--------------|--------------|-----------------------|--------------------------|----------------------------|---|---|
| GYT<br>NSA   | 99<br>107    | 16<br>LBAT 1016-18    | 'Obv.' 18'-19'<br>Rev. 7 | <b>XI</b><br><b>XI</b>     | Night of the 26th last part Venus 1 cubit 10 fingers above $\delta$ Capricorni<br>Night of the 24th last part [...] 1 cubit 8 fingers [...] [ $\delta$ Caprico]rni <sup>2</sup> | n n   |
| GYT<br>NSA   | 112<br>120   | 21<br>LBAT 1022       | 'Obv.' 6'<br>Obv. 7      | <b>II</b><br><b>II</b>     | The 21st, Venus' [last appearance] in the west in Leo<br>The 17th Venus' last appearance in the west in Gemini  | n n   |
| Diary<br>NSA | 117<br>125   | -194 B<br>LBAT 1024   | Obv. 10-11<br>Rev. 1     | <b>VII</b><br><b>VII</b>   | Night of the 8th last part Venus 2 cubits above $\alpha$ Virginis<br>Night of the 6th last part Venus [...] above 'x' <sup>1</sup>  | n n   |
| GYT<br>NSA   | 127<br>135   | 31<br>LBAT 1026       | Obv.' 11<br>Obv. 6       | <b>IX</b><br><b>IX</b>     | Night of the 3rd first part Venus 4 fingers above $\gamma$ Capricorni<br>[...] 4 fingers [...] $\gamma$ Capricorni  | n n   |
| GYT<br>NSA   | 127<br>135   | 31<br>LBAT 1026       | Obv.' 12<br>Obv. 7       | <b>IX</b><br><b>IX</b>     | Night of the 5th first part Venus 4 fingers above $\delta$ Capricorni<br>[...] 'Venus' <sup>1</sup> 4 fingers above $\delta$ Capricorni.  | n n   |
| Diary<br>NSA | 129<br>137   | -182 A<br>LBAT 1027-8 | 'Rev.' 39'<br>Rev. 6     | <b>X</b><br><b>[X]</b>     | Around the 12th, Venus [...]<br>The 8th Venus [...] in the east in 'x' <sup>1</sup> [...]   | n n   |
| Diary<br>NSA | 148<br>156   | -163 B<br>LBAT *1032  | Obv.' 13<br>Rev. 3       | <b>VIII</b><br><b>VIII</b> | Night of the 28th first part Venus 2 1/2 cubits below $\beta$ Capricorni<br>Night of the 26th first part Venus 2 1/3 <sup>2</sup> cubit below $\beta$ Capricorni                | n n   |
| Diary<br>NSA | 148<br>156   | -163 B<br>LBAT *1032  | Obv.' 24<br>Rev. 4       | <b>IX</b><br><b>IX</b>     | [Night of the 12th ...] Venus 2 fingers above $\gamma$ Capricorni<br>Night of the 10th first part Venus 1 finger above $\gamma$ Capricorni.                                     | n n   |
| Diary<br>NSA | 150<br>158   | -161 A<br>LBAT 1034-5 | 'Rev.' 8'-10'<br>Rev. 17 | <b>VI</b><br><b>VI</b>     | [Around the 26th ... Venus'] last appearance [in the west] in Libra<br>The 22nd, Venus in [...]   | n n   |

## Appendix I

|       | Year<br>(SE) | Text         |            |               |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|--------------|------------|---------------|---|---|
| Diary | 165          | -146         | 'Obv. 6'   | <b>X</b>      | [The 10th, Venus' first appearance in the west in Aquarius] ... (ideal) first appearance on the 9 <sup>th</sup> |   |
| NSA   | 173          | LBAT 1039    | Rev. 11    | <b>X</b>      | The 5th, Venus' first appearance in the west in Aquarius  | n n   |
| Diary | 167          | -144         | 'Obv. 6'   | <b>[VI]</b>   | [Around the 17th?] Venus' first appearance in the west in the end of Virgo                                      |   |
| NSA   | 175          | LBAT 1041-2  | Obv. 14    | <b>[VI?]</b>  | The 11th, Venus' first appearance in Virgo.   | n n   |
| Diary | 170          | -141 D       | 'Obv.' 5'  | <b>VI</b>     | [10th?-17th Ve]nus' last appearance in the east in Virgo  |   |
| Alm   | 178          | LBAT 1134    | Obv. 12    | <b>VI</b>     | [10th-11th] Venus' last appearance in the east in Virgo   | n n   |
| Diary | 171          | -140 A       | 'Rev. 16'  | <b>IV</b>     | The 19th, Venus' first appearance in the east in Cancer ... (ideal) first on the 15th                           |   |
| Alm   | 179          | LBAT 1136    | Obv. 3     | <b>[IV]</b>   | The 14th, Venus' first appearance in the east in Cancer   | n n   |
| GYT   | 176          | 60           | Obv.' 29   | <b>[VIII]</b> | Night of the 27th last part Venus [..]. above θ Ophiuchi  |   |
| NSA   | 184          | LBAT 1048    | Obv. 7     | <b>VIII</b>   | Night of the 25th last part Venus [...] above [θ Ophiuchi ...]  | n n   |
| Diary | 179          | -132 B       | Obv. 3     | <b>VI</b>     | Night of the 3rd ... last part Venus 1 cubit 4 fingers below α Leonis   |   |
| NSA   | 187          | LBAT 1049-50 | Obv. 9     | <b>[VI]</b>   | Night of the 2nd last part Venus 1 cubit 4 fingers below α Leonis   | n n   |
| GYT   | 179          | 63           | Obv. 11    | <b>[VI?]</b>  | [...] Venus was 1 cubit 4 fingers below alpha Leonis  |   |
| NSA   | 187          | LBAT 1049-50 | Obv. 9     | <b>[VI]</b>   | Night of the 2nd last part Venus 1 cubit 4 fingers below α Leonis   | n n   |
| GYT   | 180          | 65           | 'Obv.' 10' | <b>[XII?]</b> | Around the 3rd, Venus' last appearance [in] the west in Pisces  |   |
| NSA   | 188          | LBAT 1051    | Rev. 20    | <b>XI</b>     | The 29th, Venus' last appearance in the west in Pisces.   | n n   |
| Diary | 181          | -130 D       | Rev.' 12   | <b>XII</b>    | [15th] first part Venus 1 ½ cubits below η Tauri  |   |
| NSA   | 189          | LBAT **1055  | Rev. 68    | <b>XII</b>    | Night of the 13th first part Venus 1 ½ cubits below η Tauri   | n n   |

|       | Year<br>(SE) | Text        |            |                        |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------|--------------|-------------|------------|------------------------|---|---|
| Diary | 181          | -130 D      | Rev.' 18   | <b>XII</b>             | Night of the 25th first part Venus [...]  |   |
| NSA   | 189          | LBAT **1055 | Rev. 71    | <b>XII</b>             | Night of the 23rd first part Venus 2 ½ cubits above α Tauri                     | n n   |
| GYT   | 184          | 68          | 'Obv.' 9'  | <b>VI</b>              | Night of the 7th last part Venus 5 cubits below θ Leonis                        |   |
| NSA   | 192          | LBAT 1056   | Obv. 5     | <b>VI</b>              | Night of the 5th last part Venus 5 cubits 'x' 0 [Leonis <sup>2</sup> ]          | n n   |
| GYT   | 184          | 68          | 'Obv.' 10' | <b>VI</b>              | [Ni]ght of the 20+[xth last part] Venus 2/3 <sup>2</sup> cubit below γ Virginis |   |
| NSA   | 192          | LBAT 1056   | Obv. 9     | <b>VI</b>              | [...] last part Venus 1/3 cubit below γ 'Vir'ginis                              | n n   |
| GYT   | 184          | 68          | 'Obv.' 11' | <b>VII</b>             | Night of the 29th last part Venus 2 ½ cubits below β Librae                     |   |
| NSA   | 192          | LBAT 1056   | Rev. 5     | <b>VII</b>             | [Night] of the 27th last part Venus 2 ½ cubits below β Librae.                  | n n   |
| GYT   | 184          | 68          | 'Obv.' 11' | <b>VIII</b>            | Night of the 10th last part Venus 8 fingers above β Scorpii                     |   |
| NSA   | 192          | LBAT 1056   | Rev. 7-8   | <b>VIII</b>            | Night of the 8th last part Venus [...] 'above' 1 β [Scorpii <sup>2</sup> ...]   | n n   |
| GYT   | 186          | 69          | Obv. 8     | <b>II</b>              | Night of the 4th last part Venus 4 cubits below η Piscium                       |   |
| NSA   | 194          | LBAT 1057   | Obv. 5-6   | <b>II</b>              | Night of the 2nd last part Venus 4 cubits below [η] Piscium                     | n n   |
| GYT   | 186          | 69          | Obv. 9     | <b>II</b>              | Night of the 9th last part Venus 5 cubits below β Arietis                       |   |
| NSA   | 194          | LBAT 1057   | Obv. 7     | <b>II</b>              | Night of the 8th last part Venus '4' <sup>1</sup> [...] below β Arietis         | n n   |
| GYT   | 186          | 69          | Obv. 9     | <b>II</b>              | Night of the 13th last part Venus 6 <sup>2</sup> [cubits] below α Arietis       |   |
| NSA   | 194          | LBAT 1057   | Obv. 9     | <b>II</b>              | Night of the 12th last part 'Venus' 6 cubits below α Arietis.                   | n n   |
| GYT   | 186          | 69          | Obv. 10    | <b>III<sup>2</sup></b> | Night of the 10th last part Venus 2 cubits above α Tauri                        |   |
| NSA   | 194          | LBAT 1057   | Obv. 13    | <b>III</b>             | Night of the 9th last part Venus 2 cubits above α Tauri.                        | n n   |

|     | Year<br>(SE) | Text      |            |                        |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-----|--------------|-----------|------------|------------------------|--|---|
| GYT | 186          | 69        | Obv. 10    | <b>III<sup>?</sup></b> | Night of the 20th last part Venus 2 ½ cubits below β Tauri                     |   |
| NSA | 194          | LBAT 1057 | Obv. 13-14 | <b>III</b>             | Night of the 19th <sup>?</sup> last part Venus 2 ½ cubits below β Tauri        | n n   |
| GYT | 186          | 69        | Obv. 11    | <b>IV</b>              | Night of the 1st [last part Ve]nus 8 fingers above η Geminorum                 |   |
| NSA | 194          | LBAT 1057 | Obv. 15    | <b>III</b>             | Night of the 30th last part Venus 8 fingers above η Geminorum.                 | n n   |
| GYT | 186          | 69        | Obv. 12    | <b>IV</b>              | Night of the 6th last part Venus 2 <sup>?</sup> cubits above γ Geminorum       |   |
| NSA | 194          | LBAT 1057 | Obv. 18    | <b>IV</b>              | Night of the 5th last part Venus 3 cubits above γ Geminorum.                   | n n   |
| GYT | 186          | 69        | Obv. 13    | <b>IV</b>              | Night of the 15th <sup>?</sup> [last part Venus] 4 cubits [below] α Geminorum  |   |
| NSA | 194          | LBAT 1057 | Obv. 19    | <b>IV</b>              | Night of the 13th last part Venus 4 cubits below α Geminorum                   | n n   |
| GYT | 186          | 69        | Obv. 13    | <b>IV</b>              | Night of the 18th last part Venus 5 cubits below β Geminorum                   |   |
| NSA | 194          | LBAT 1057 | Obv. 20    | <b>IV</b>              | Night of the 17th <sup>?</sup> last part Venus 3 cubits below β Geminorum.     | n n   |
| GYT | 186          | 69        | Obv. 15    | <b>XI</b>              | Night of the xth first part Venus 2 ½ cubits below η Piscium                   |   |
| NSA | 194          | LBAT 1057 | Rev. 10    | <b>XI</b>              | Night of the 28th first part Venus 2 ½ cubits below η Piscium.                 | n n   |
| GYT | 186          | 69        | Obv. 15-16 | <b>[XII]</b>           | [... Venus] 3 ½ cubits [below] β Arietis                                       |   |
| NSA | 194          | LBAT 1057 | Rev. 12    | <b>XII</b>             | Night of the 5th first part Venus 3 ½ cubits below [β] Arietis.                | n n   |
| GYT | 186          | 69        | Obv. 16    | <b>[XII]</b>           | Ni[ght of the xth first part] Venus 4 ½ cubits below α Arietis                 |   |
| NSA | 194          | LBAT 1057 | Rev. 13    | <b>XII</b>             | Night of the 9th first part Venus 4 ½ cubits below α Ari[etis]                 | n n   |
| GYT | 186          | 69        | Obv. 16    | <b>[XII]</b>           | Night of the 10+[xth first part Venus] 1 <sup>?</sup> ½ cubits [below η Tau]ri |   |
| NSA | 194          | LBAT 1057 | Rev. 14    | <b>XII</b>             | [... x+]5th first part Venus 1 ½ cubits below η Tauri                          | n n   |

|       | Year<br>(SE) | Text        |            |                        |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-------------|------------|------------------------|---|---|
| GYT   | 186          | 69          | Obv. 17    | <b>XII<sub>2</sub></b> | Night of the 14th <sup>?</sup> first part Venus [...] below [β] Tauri   |   |
| NSA   | 194          | LBAT 1057   | Rev. 19    | <b>XII<sub>2</sub></b> | Night of the 15th first part Venus [...] below [β] Tauri  | n n   |
| Diary | 187          | -124 A      | 'Obv.' 11' | <b>II</b>              | Night of the 4th first part Venus [...] above [θ <sup>?</sup> Cancrī ...]   |   |
| NSA   | 195          | LBAT 1058   | Obv. 4     | <b>II</b>              | Night of the 3rd first part Venus ...   | n n   |
| Diary | 193          | -118 A      | Obv.' 24   | <b>II</b>              | Night of the 3rd first part of the night, Venus was ½ cubit above μ Geminorum   |   |
| NSA   | 201          | LBAT **1059 | Obv. 8     | <b>II</b>              | Night of the 2nd first part Venus ½ cubit above μ Geminorum   | n n   |
| Diary | 193          | -118 A      | Obv.' 25   | <b>II</b>              | Night of the 5th first part [of the night, Ven]us was [...] above γ Geminorum;  |   |
| NSA   | 201          | LBAT **1059 | Obv. 9     | <b>II</b>              | Night of the 5th first part Venus ½ cubit above γ Geminorum   | n n   |
| Diary | 200          | -111 A      | Obv.' 6    | <b>I</b>               | Around the 10th, Venus' [last appearance] in the west in Taurus; around the 19th, Venus' first appearance in the east in Taurus |   |
| NSA   | 208          | BM 32230    | Obv. 6     | <b>II</b>              | The 16th, Venus [...]   | y y   |
| Diary | 225          | -86 B       | Line 20'   | <b>VIII</b>            | The 28th, Venus' first appearance in the east in Sagittarius ... (ideal) first on the 24th                                      |   |
| Alm   | 233          | LBAT 1160   | Rev. 2     | <b>[VIII]</b>          | The 20th, Venus' first appearance in the east in Sagittarius.   | n n   |
| GYT   | 228          | 86          | Obv. 12    | <b>II</b>              | Around the 11th, Venus' first appearance in the west in Gemini  |   |
| Alm   | 236          | LBAT 1174   | Obv. 3     | <b>II</b>              | The 6th, Venus' 'first appearance' in the west in Gemini  | n n   |
| GYT   | 228          | 86          | Obv. 18    | <b>XI</b>              | Around the 10th, Venus' last appearance in the west in the end of Aquarius  |   |
| Alm   | 236          | LBAT 1174   | Rev. 7     | <b>XI</b>              | The 6th, Venus' last appearance in the west in Aquarius   | n n   |
| GYT   | 228          | 86          | Obv. 19    | <b>XI</b>              | The 15th, Venus' first appearance in the east in Aquarius ... (ideal) first appearance on the 12 <sup>th</sup>                  |   |
| Alm   | 236          | LBAT 1174   | Rev. 7     | <b>XI</b>              | The 8th, Venus' first appearance in the east in Aquarius.   | n n   |



|                | Year<br>(SE) | Text          |            |             |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|----------------|--------------|---------------|------------|-------------|---|---|
| GYT            | 237          | 88            | 'Obv. 5'   | <b>X</b>    | Around the 5th, Venus' [first appearance in the west in ...]  |   |
| Alm            | 245          | LBAT *1079-80 | Rev. 18    | <b>IX</b>   | [25th-28th x Venus'] first appearance [in the west in x].   | n n   |
| Mercury events |              |               |            |             |   |   |
| GYT            | 50           | 10            | Obv.' 22   | <b>I</b>    | The 7th, Mercury's first appearance in the west in the beginning of Taurus                                  |   |
| NSA            | 96           | LBAT **1007   | Obv. 1     | <b>I</b>    | 'The 14th', Mercury in the west in the beginning of [...]   | n n   |
| GYT            | 50           | 10            | Obv.' 23   | <b>I</b>    | Night of the 25th first part Mercury 1 cubit 4 fingers below $\beta$ Tauri                                  |   |
| NSA            | 96           | LBAT **1007   | Obv. 4     | <b>I</b>    | Night of the 24th first [part] Mercury [...] below $\beta$ Tauri  | n n   |
| GYT            | 50           | 10            | Obv.' 24   | <b>I</b>    | [...] first part Mercury 1 5/6 cubits above $\zeta$ Tauri   |   |
| NSA            | 96           | LBAT **1007   | Obv. 5     | <b>I</b>    | Night of the 26th first part Mercury 1 1/3 cubits above $\zeta$ Tau(ri)                                     | n n   |
| GYT            | 50           | 10            | Obv.' 25   | <b>II</b>   | The 13th, Mercury's last appearance in the west in the beginning of Gemini                                  |   |
| NSA            | 96           | LBAT **1007   | Obv. 6     | <b>II</b>   | The 13th, Mercury's last appearance in the west in Gemini.  | n n   |
| Diary          | 50           | -261 B        | 'Obv.' 9'  | <b>IX</b>   | The 20th, Mercury's first appearance in the west in Capricorn ... (ideal) first on 19th or 18 <sup>th</sup> |   |
| NSA            | 96           | LBAT 1008     | Rev. 8     | <b>IX</b>   | The 18th, Mercury's [first appearance ...] in Capricorn   | n n   |
| GYT            | 61           | 16            | 'Obv.' 21' | <b>III</b>  | The 30th, [Mercury's] last appearance [in the west in] Cancer   |   |
| NSA            | 107          | LBAT 1016-18  | Obv. 13    | <b>III</b>  | The 29th, Mercury in the west in Cancer last appearance.  | n n   |
| GYT            | 61           | 16            | 'Obv.' 21' | <b>IV</b>   | The 24th, Mercury's [first appearance] in [the east in ...]   |   |
| NSA            | 107          | LBAT 1016-18  | Obv. 16    | <b>IV</b>   | The 24th, 'Mercury x first appearance' <sup>1</sup>   | n n   |
| Diary          | 62           | -249 B        | 'Obv.' 3'  | <b>IX</b>   | Around the 20th, Mercury's first appearance in the west in Capricorn  |   |
| NSA            | 108          | LBAT 1019     | Rev. 5     | <b>[IX]</b> | The 20th, Mercury's first appearance in the west in Capricorn   | n n   |

## Appendix I

|       | Year<br>(SE) | Text      |           |                        |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-----------|-----------|------------------------|---|---|
| Diary | 65           | -246      | Obv.' 13  | <b>II</b>              | The 5th, Mercury's first appearance in the east, omitted                |   |
| NSA   | 111          | LBAT 1020 | Obv. 4    | <b>II</b>              | The '7th', Mercury's first appearance in the east, omitted              | n n   |
| Diary | 65           | -246      | 'Rev. 10' | <b>VI</b>              | The 12th, Mercury's [last appearance] in the ea[st in Virgo...]         |   |
| NSA   | 111          | LBAT 1020 | Obv. 13   | <b>VI</b>              | The 12th, Mercury's last appearance in the east in Virgo                | n n   |
| Diary | 79           | -232      | Obv. 28   | <b>IX</b>              | Night of the 9th last part Mercury [...] above θ O[phiuchi]             |   |
| NSA   | 125          | LBAT 1024 | Rev. 5    | <b>[IX]</b>            | Night of the 8th last part Mercury [...]                                | n n   |
| GYT   | 83           | 27        | Obv. `7   | <b>I</b>               | The 11th, Mercury's first appearance in the west in Taurus <sup>?</sup> |   |
| Alm   | 129          | LBAT 1123 | Obv. 1    | <b>I</b>               | The 12th, Mercury's first appearance in the west in Taurus              | n n   |
| GYT   | 83           | 27        | Obv. 19   | <b>II<sup>?</sup></b>  | The xth, Mercury's last appearance in the west in Gemini                |   |
| Alm   | 129          | LBAT 1123 | Obv. 5    | <b>II</b>              | The 21st, Mercury's last appearance in the west in Gemini               | n n   |
| GYT   | 83           | 27        | Obv. 19   | <b>III<sup>?</sup></b> | The 26th <sup>?</sup> , Mercury's [first appearance] in the east ...    |   |
| Alm   | 129          | LBAT 1123 | Obv. 6    | <b>III</b>             | The 24th, Mercury's first appearance in the east in Gemini.             | n n   |
| GYT   | 83           | 27        | Obv. 20   | <b>[IV]</b>            | [...] Mercury's last appearance in the west in the end of Gemini        |   |
| Alm   | 129          | LBAT 1123 | Obv. 7    | <b>IV</b>              | The 9th, Mercury's last appearance in the east in the end of Gemini     | n n   |
| GYT   | 83           | 26        | 'Obv.' 3' | <b>V<sup>?</sup></b>   | The 11th, Mercury's first appearance in the west in the end of Leo      |   |
| Alm   | 129          | LBAT 1123 | Obv. 9    | <b>V</b>               | The 11th, Mercury's first appearance in the west in the end of Leo.     | n n   |
| GYT   | 83           | 27        | Obv. 21   | <b>VII</b>             | The 7th, Mercury's first appearance in the east in Virgo                |   |
| Alm   | 129          | LBAT 1123 | Obv. 12   | <b>[VII]</b>           | The 5th, Mercury 'xxx' [...]  | n n   |

|              | Year<br>(SE) | Text                  |                      |  |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|--------------|--------------|-----------------------|----------------------|--|--|---|
| GYT<br>Alm   | 83<br>129    | 26<br>LBAT 1123       | 'Obv.' 7'<br>Rev. 2  | <b>[XII]</b><br><b>[XII]</b>                     | Around the 7th, Mercury's [last appearance] in the east in ...<br>[1st-14th] Mercury's last appearance in the east in Aquarius.  | n n   |
| GYT<br>Alm   | 83<br>129    | 27<br>LBAT 1123       | Obv. 25<br>Rev. 4    | <b>XII<sub>2</sub></b><br><b>XII<sub>2</sub></b> | The 6th, Mer[cury's first appearance in the west in Aries]<br>The 7th, Mercury's first appearance in the west in Aries.  | n n   |
| Diary<br>NSA | 104<br>150   | -207 A<br>LBAT *1030  | Obv.' 16<br>Obv. 3-4 | <b>I</b><br><b>I</b>                             | The 20th <sup>?</sup> , Mercury's last appearance in the west in Taurus<br>The 1[9th <sup>?</sup> Mercury's] last appearance [in the west in Tau]rus.                  | n n   |
| Diary<br>NSA | 104<br>150   | -207 A<br>LBAT *1030  | Obv.' 31<br>Obv. 8   | <b>II</b><br><b>II</b>                           | The 19th, Mercury's first appearance in the east ... omitted<br>The 19th, last part Mercury's [first appearance] in the east in Tau[rus (omitted <sup>?</sup> )]       | n n   |
| Diary<br>NSA | 104<br>150   | -207 A<br>LBAT *1030  | Obv.' 34<br>Obv. 10  | <b>III</b><br><b>III</b>                         | The 5th, Mercury's last appearance in the east ... omitted<br>x last part Mercury's last appearance in the east in Gemini [omitted <sup>?</sup> ]                      | n n   |
| Diary<br>NSA | 110<br>156   | -201 B<br>LBAT *1032  | Rev. 5-6<br>Rev. 7   | <b>X</b><br><b>X</b>                             | The 13th, Mercury's first appearance in the east in Sagittarius ... (ideal) first on the 8th<br>9th ...last part Mercury's first appearance in the east in Sagittarius | n n   |
| Diary<br>NSA | 129<br>175   | -182 A<br>LBAT 1041-2 | 'Rev.' 38'<br>Rev. 7 | <b>X</b><br><b>[X]</b>                           | The 17th, Mercury's first appearance in the east in Capricorn<br>The 24th, Mer[cury's] first appearance [...] in Capricorn   | n n   |
| Diary<br>Alm | 133<br>179   | -178 A<br>LBAT 1136   | Obv.' 9<br>Obv. 6    | <b>V</b><br><b>V</b>                             | [10th ... Mercury's] last appearance [in the east] in Leo<br>The 10th, Mercury's last appearance in the east in Leo  | n n   |
| Diary<br>Alm | 133<br>179   | -178 C<br>LBAT 1135   | Obv.' 9<br>Rev. 2    | <b>XI</b><br><b>[XI]</b>                         | [The 11th], Mercury's last appearance in the west in P[isces <sup>?</sup> ]<br>The 11th, Mercury's last appearance in the west in Pisces.                              | n n   |

|              | Year<br>(SE) | Text                  |                         |                                    |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|--------------|--------------|-----------------------|-------------------------|------------------------------------|---|---|
| Diary<br>Alm | 133<br>179   | -178 C<br>LBAT 1135   | 'Rev. 13'<br>Rev. 6     | <b>XII</b><br><b>[XII]</b>         | The 29th, Mercury's last appearance in the east in the end of Pisces<br>The 29th, Mercury's last appearance in the east [...].                        | n n   |
| Diary<br>NSA | 138<br>184   | -173 A<br>LBAT 1048   | 'Rev. 5'<br>Rev. 25     | <b>XII</b><br><b>XII</b>           | The 3rd, Mercury's last appearance in the west in Aries<br>The 3rd, Mercury's last appearance in the west in Aries.                                   | n n   |
| Diary<br>NSA | 143<br>189   | -168 A<br>LBAT **1055 | Obv.' 12<br>Obv. 37-38  | <b>V</b><br><b>VI</b>              | 27th, first appearance in the east in Virgo ... (ideal) first on the 25th<br>The 25th, Mercury's first appearance in the east in Virgo                | y y   |
| Diary<br>NSA | 143<br>189   | -168 A<br>LBAT **1055 | Obv.' 19<br>Rev. 40     | <b>VI</b><br><b>VI<sub>2</sub></b> | Night of the 11th last part Mercury 1 cubit 8 fingers [below] γ Virginis<br>Night of the 10th ...last part Mercury 1 cubit 8 fingers below γ Virginis | y y   |
| Diary<br>NSA | 143<br>189   | -168 A<br>LBAT **1055 | Obv.' 25<br>Rev. 43     | <b>VI</b><br><b>VI<sub>2</sub></b> | 23rd last appearance in the east in the beginning of Libra<br>The 23rd, Mercury's last appearance in the east in Libra.                               | y y   |
| Diary<br>NSA | 143<br>189   | -168 A<br>LBAT **1055 | Rev. 10'-11'<br>Rev. 48 | <b>VIII</b><br><b>VIII</b>         | Around the 15th <sup>2</sup> first appearance in the west in Sagittarius<br>The 14th, Mercury's first appearance in the west in Sagittarius.          | n n   |
| Diary<br>NSA | 143<br>189   | -168 E<br>LBAT **1055 | Obv.' 2-3<br>Rev. 51    | <b>IX</b><br><b>IX</b>             | 2nd, last appearance in the west in Capricorn<br>The 2nd, Mercury's last appearance in the west in Capricorn  | n n   |
| Diary<br>Alm | 143<br>189   | -168 A<br>LBAT 1141-2 | Obv.' 12<br>Obv. 12     | <b>V</b><br><b>VI</b>              | The 27th, Mercury's first appearance in the <east> in Virgo ... (ideal) first on 25th<br>[~26th] 'xxxx' <sup>1</sup> first appearance in Virgo        | y y   |
| Diary<br>Alm | 143<br>189   | -168 A<br>LBAT 1141-2 | Obv.' 25<br>Obv. 13     | <b>VI</b><br><b>[VII]</b>          | [The 23rd, Mercury's] last appearance in the east in the beginning of Libra<br>'xx' <sup>1</sup> Mercury's last appearance in Virgo.                  | y y   |

|       | Year<br>(SE) | Text      |                |            |  | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------|--------------|-----------|----------------|------------|--|---|
| GYT   | 146          | 68        | 'Obv.' 16'-17' | <b>VII</b> | The 29th, Mercury's first appearance in the east in the beginning of Scorpio [...] ideal first appearance on the 27th <sup>2</sup> |   |
| NSA   | 192          | LBAT 1056 | Rev. 4         | <b>VII</b> | The 24th, Mercury in the east in Scor[pio ...]   | n n   |
| Diary | 148          | -163 A    | Obv.' 2        | <b>II</b>  | The 1st ... first part of the night Mercury 1 ½ [cubits] below β Tauri   |   |
| NSA   | 194          | LBAT 1057 | Obv. 5         | <b>II</b>  | Night of the 1st first part Mercury 'xxx' below [β] Tauri  | n n   |
| GYT   | 148          | 69        | Obv. 21        | <b>II</b>  | Night of the 2nd first part Mercury 1 ½ cubits below β Tauri   |   |
| NSA   | 194          | LBAT 1057 | Obv. 5         | <b>II</b>  | Night of the 1st first part Mercury 'xxx' below [β] Tauri  | n n   |
| Diary | 148          | -163 A    | Obv.' 4        | <b>II</b>  | Night of the 3rd ... first part of the night Mercury [...] above ζ [Tauri]   |   |
| NSA   | 194          | LBAT 1057 | Obv. 6         | <b>II</b>  | Night of the 3rd first part Mercury 1 ½ [...] above ζ Tauri  | n n   |
| Diary | 148          | -163 A    | Obv.' 11       | <b>II</b>  | Night of the 9th ... first part Mercury [... above η Geminorum]  |   |
| NSA   | 194          | LBAT 1057 | Obv. 8         | <b>II</b>  | Night of the 9th first part Mercury 1 'cubit x' fingers <sup>2</sup> above [η] Geminorum   | n n   |
| GYT   | 148          | 69        | Obv. 22        | <b>II</b>  | Night of the 9th first part Mercury 1 cubit 4 fingers above η Geminorum  |   |
| NSA   | 194          | LBAT 1057 | Obv. 8         | <b>II</b>  | Night of the 9th first part Mercury 1 'cubit x' fingers <sup>2</sup> above [η] Geminorum   | n n   |
| Diary | 148          | -163 A    | Obv.' 13-14    | <b>II</b>  | Night of the 11th ... first part Mercury 1 2/3 cubits above μ Geminorum  |   |
| NSA   | 194          | LBAT 1057 | Obv. 8         | <b>II</b>  | Night of the 11th first part Mercury 1 cubit 4 fingers <sup>2</sup> above μ Geminorum  | n n   |
| GYT   | 148          | 69        | Obv. 22-23     | <b>II</b>  | Night of the 11th first part Mercury 1 cubit 4 fingers above μ Geminorum   |   |
| NSA   | 194          | LBAT 1057 | Obv. 8         | <b>II</b>  | Night of the 11th first part Mercury 1 cubit 4 fingers <sup>2</sup> above μ Geminorum  | n n   |
| Diary | 148          | -163 A    | Obv.' 18       | <b>II</b>  | Night of the 15th ... first part Mercury 4 ½ cubits [above γ Geminorum]  |   |
| NSA   | 194          | LBAT 1057 | Obv. 10        | <b>II</b>  | Night of the 14th first [part ...] 'x' Geminorum 'xxx'   | n n   |

|       | Year<br>(SE) | Text      |            |           |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-----------|------------|-----------|---|---|
| GYT   | 148          | 69        | Obv. 24    | <b>IV</b> | The 7th, Mercury's first appearance in the east in Gemini ... [(ideal) first appearance] on the 4 <sup>th</sup>   |   |
| NSA   | 194          | LBAT 1057 | Obv. 18    | <b>IV</b> | The 4th, Mercury's first appearance in the east 'xx'  | n n   |
| GYT   | 148          | 69        | Obv. 25    | <b>IV</b> | The 23rd, Mercury's last appearance in the east in Cancer   |   |
| NSA   | 194          | LBAT 1057 | Obv. 21    | <b>IV</b> | [...x+]3rd Mercury's last appearance in the east in Cancer.   | n n   |
| Diary | 148          | -163 C    | 'Obv. 15'  | <b>X</b>  | [... Mercury's] first appearance [in the west] in Capricorn   |   |
| NSA   | 194          | LBAT 1057 | Rev. 5     | <b>X</b>  | The 3rd, Mercury's first appearance in the west in Capricorn  | n n   |
| GYT   | 148          | 69        | Obv. 28    | <b>X</b>  | The 5th, Mercury's first appearance in the west in Capricorn ... (ideal) first appearance on the 4 <sup>th</sup>  |   |
| NSA   | 194          | LBAT 1057 | Rev. 5     | <b>X</b>  | The 3rd, Mercury's first appearance in the west in Capricorn  | n n   |
| Diary | 148          | -163 C    | 'Obv. 15'  | <b>X</b>  | Around the 20th, Mercury's last appearance in the west in Aquarius  |   |
| NSA   | 194          | LBAT 1057 | Rev. 6     | <b>X</b>  | The 20th, Mercury in the west in Aquarius 'x' [...]   | n n   |
| GYT   | 148          | 69        | Obv. 28-29 | <b>X</b>  | [...Mercury's last appearance in the west] in Aquarius: from the 20th, when I watched I did not see it            |   |
| NSA   | 194          | LBAT 1057 | Rev. 6     | <b>X</b>  | The 20th, Mercury in the west in Aquarius 'x' [...]   | n n   |
| Diary | 148          | -163 C    | Rev.' 4    | <b>XI</b> | The 10th, Mercury's [first] appearance in the east in Capricorn   |   |
| NSA   | 194          | LBAT 1057 | Rev. 8     | <b>XI</b> | The 8th, Mercury's first appearance in the east in Capricorn.   | n n   |
| GYT   | 148          | 69        | Obv. 29    | <b>XI</b> | The 10th, Mercury's first appearance in the east in Capricorn,... (ideal) first appearance on the 8 <sup>th</sup> |   |
| NSA   | 194          | LBAT 1057 | Rev. 8     | <b>XI</b> | The 8th, Mercury's first appearance in the east in Capricorn.   | n n   |
| GYT   | 148          | 69        | Obv. 30    | <b>XI</b> | Night of the 25th last part Mercury 1/2 cubit above γ Capricorni  |   |
| NSA   | 194          | LBAT 1057 | Rev. 8-9   | <b>XI</b> | Night of the 24th last part Mercury 1/2 cubit above 'x' [...] Capricorni  | n n   |

## Appendix I

|       | Year<br>(SE) | Text        |            |            |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-------------|------------|------------|--|---|
| GYT   | 148          | 69          | Obv. 31    | <b>XI</b>  | Night of the 27th last part Mercury 1/2 cubit above $\delta$ Capricorni  |   |
| NSA   | 194          | LBAT 1057   | Rev. 9-10  | <b>XI</b>  | Night of the 26th last part Mercury above $\delta$ [Capricorni ...]  | n n   |
| Diary | 148          | -163 C      | 'Rev.' 3'  | <b>XII</b> | Around the 14th, Mercury's last appearance in the east in Aquarius (alt: "the end of Aquarius")                                  |   |
| NSA   | 194          | LBAT 1057   | Rev. 14    | <b>XII</b> | [x+]5th Mercury's last appearance in the east in the end of Aquarius.  | n n   |
| GYT   | 148          | 69          | Obv. 31-32 | <b>XII</b> | The 17th, Mercury's last appearance in the east in Pisces, from the 14th in the end of Aquarius, when I watched I did not see it |   |
| NSA   | 194          | LBAT 1057   | Rev. 14    | <b>XII</b> | [x+]5th Mercury's last appearance in the east in the end of Aquarius.  | n n   |
| GYT   | 155          | 73          | Obv. 31'   | <b>[I]</b> | Night of the 9th first part Mercury 1 cubit above $\alpha$ Tauri   |   |
| NSA   | 201          | LBAT **1059 | Obv. 2-3   | <b>I</b>   | Night of the 8th first part Mercury 4 cubits above $\alpha$ Tauri.   | n n   |
| GYT   | 155          | 73          | Obv. 32'   | <b>[I]</b> | Night of the 17th <sup>?</sup> first part [Mercury ...] below $\beta$ Tauri  |   |
| NSA   | 201          | LBAT **1059 | Obv. 3-4   | <b>I</b>   | Night of the 16th first part Mercury 1 1/2 cubits below $\beta$ Tauri  | n n   |
| Diary | 155          | -156 A      | 'Obv.' 8'  | <b>I</b>   | Night of the 19th first part Mercury 1 1/2 cubits above $\zeta$ Tauri  |   |
| NSA   | 201          | LBAT **1059 | Obv. 4     | <b>I</b>   | Night of the 18th first part Mercury 1 1/2 cubits above $\zeta$ Tauri  | n n   |
| GYT   | 155          | 73          | Obv. 32'   | <b>[I]</b> | [Night of the 1]9th first part Mercury 1 1/2 cubits above $\zeta$ Tauri  |   |
| NSA   | 201          | LBAT **1059 | Obv. 4     | <b>I</b>   | Night of the 18th first part Mercury 1 1/2 cubits above $\zeta$ Tauri  | n n   |
| Diary | 155          | -156 A      | 'Obv.' 12' | <b>I</b>   | [26th] first part Mercury 1 cubit 4 fingers above $\eta$ Geminorum   |   |
| NSA   | 201          | LBAT **1059 | Obv. 5     | <b>I</b>   | Night of the 25th first part Mercury 1 cubit 4 fingers above $\eta$ Geminorum  | n n   |
| GYT   | 155          | 73          | Obv. 33'   | <b>[I]</b> | Night of the 10+[xth first part Mercury] 1 cubit 4 fingers [above $\eta$ Geminorum]  |   |
| NSA   | 201          | LBAT **1059 | Obv. 5     | <b>I</b>   | Night of the 25th first part Mercury 1 cubit 4 fingers above $\eta$ Geminorum  | n n   |

|       | Year<br>(SE) | Text        |              |              |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-------------|--------------|--------------|---|---|
| Diary | 155          | -156 A      | 'Obv.' 14'   | <b>I</b>     | [28th] first part Mercury [...] above $\mu$ Geminorum   |   |
| NSA   | 201          | LBAT **1059 | Obv. 5-6     | <b>I</b>     | Night of the 27th first part Mercury 1 cubit 4 fingers above $\mu$ Geminorum.                                     | n n   |
| GYT   | 155          | 73          | Obv. 34'     | <b>[II]</b>  | Night of the 28th first part Mercury [...] above $\mu$ Ge[minorum]  |   |
| NSA   | 201          | LBAT **1059 | Obv. 5-6     | <b>I</b>     | Night of the 27th first part Mercury 1 cubit 4 fingers above $\mu$ Geminorum.                                     | n n   |
| GYT   | 155          | 73          | Obv. 34'-35' | <b>[III]</b> | [Night of the xth first part Mercury] 4 cubits above $\gamma$ Geminorum   |   |
| NSA   | 201          | LBAT **1059 | Obv. 8-9     | <b>II</b>    | 2nd first part Mercury 4 cubits above $\gamma$ Geminorum  | n n   |
| GYT   | 155          | 73          | Obv. 35'-36' | <b>[III]</b> | [The xth, Mercury's first appearance in the east in Gemini], ... (ideal) first appearance on the 14 <sup>th</sup> |   |
| NSA   | 201          | LBAT **1059 | Obv. 15      | <b>III</b>   | The 14th Mercury's first appearance in the west in Gemini.  | n n   |
| GYT   | 155          | 73          | Obv. 37'     | <b>V</b>     | Around the 5th, Mercury's first appearance in the west in Vir[go <sup>?</sup> ]                                   |   |
| NSA   | 201          | LBAT **1059 | Obv. 26      | <b>V</b>     | The 5th, Mercury's first appearance in the west in Virgo.   | n n   |
| GYT   | 155          | 73          | Obv. 37'     | <b>V</b>     | Around the 27th, [Mercury's last appearance in the west in ...]   |   |
| NSA   | 201          | LBAT **1059 | Obv. 30      | <b>V</b>     | The 27th, Mercury's last appearance in the west in Virgo.   | n n   |
| GYT   | 155          | 73          | Obv. 38'     | <b>VI</b>    | The 28th, Mercury's [first appearance] in the east in Virgo   |   |
| NSA   | 201          | LBAT **1059 | Rev.. 37     | <b>VI</b>    | The 26th, Mercury's first appearance in the east in Virgo   | n n   |
| GYT   | 155          | 73          | Obv. 38'     | <b>[VII]</b> | [Night of the 6th <sup>?</sup> , last part Mercury] 2 cubits [above] $\alpha$ Virginis                            |   |
| NSA   | 201          | LBAT **1059 | Rev. 36      | <b>VII</b>   | Night of the 7th last part Mercury 2 cubits above $\alpha$ Virginis.  | n n   |
| GYT   | 155          | 73          | Obv. 40'     | <b>[IX]</b>  | The 9th <sup>?</sup> Mercury's [first appearance] in the west in [Capricorn ...]                                  |   |
| NSA   | 201          | LBAT **1059 | Rev. 50      | <b>IX</b>    | The 13th, Mercury's first appearance in the west in Capricorn   | n n   |



|       | Year<br>(SE) | Text        |            |                       |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-------------|------------|-----------------------|--|---|
| GYT   | 155          | 73          | Rev. 1-2   | <b>[X]</b>            | [The xth, Mercury's first appearance] in the east in Capricorn, 1 cubit behind $\beta$ Capricorni ... (ideal) first appearance on the 14th |   |
| NSA   | 201          | LBAT **1059 | Rev. 54    | <b>X</b>              | The 14th, Mercury's first appearance in the east in Capricorn(?).  | n n   |
| GYT   | 155          | 73          | Rev. 3     | <b>XI</b>             | The 28th, Mercury's last appearance in the east in Aquarius, from the 26th, when I watched I did not see it                                |   |
| NSA   | 201          | LBAT **1059 | Rev. 61    | <b>XI</b>             | The 26th, Mercury's last appearance in the east in Capricorn   | n n   |
| GYT   | 156          | 73          | Rev. 4     | <b>[I]</b>            | The 1st, Mercury's first appearance in the west in Aries   |   |
| NSA   | 201          | LBAT **1059 | Rev. 70    | <b>XII</b>            | The 29th, Mercury's first appearance in the west in Aries.   | n n   |
| Diary | 163          | -148        | Line 8'    | <b>IX</b>             | The 22nd, Mercury's first appearance in the east in Sagittarius  |   |
| Alm   | 209          | LBAT 1153   | Rev. 3     | <b>IX</b>             | The 12th, Mercury's first [appearance] in the east in Sagittarius  | n n   |
| Diary | 174          | -137 D      | Rev.' 29   | <b>XI</b>             | Around the 2nd, Mercury's first appearance in the east in the end of Capricorn   |   |
| Alm   | 220          | LBAT 1158   | Rev. 2     | <b>[XI]</b>           | The 2 <sup>nd</sup> , Mercury 'xxx'  | n n   |
| Diary | 180          | -131 B      | Obv. 2-4   | <b>XI</b>             | The 22nd, Mercury's first appearance in the east in Aquarius ... (ideal) first on the 19th   |   |
| Alm   | 226          | LBAT 1159   | Obv. 5     | <b>XI<sup>?</sup></b> | [...] Mercury's first appearance in the east in Aquarius   | n n   |
| Diary | 187          | -124 A      | 'Obv.' 22' | <b>II</b>             | The 22nd, Mercury's last appearance in the west in the beginning of Cancer   |   |
| Alm   | 233          | LBAT 1160   | Obv. 3     | <b>[II]</b>           | The 22nd, Mercury's last appearance in the west in the beginning of Cancer   | n n   |
| Diary | 187          | -124 A      | 'Obv.' 33' | <b>III</b>            | Around the 22nd, Mercury's [first appearance in the east in Gemini ...]  |   |
| Alm   | 233          | LBAT 1160   | Obv. 5     | <b>[III]</b>          | The 22nd, Mercury's first appearance in the east in the end of Gemini  | n n   |
| Diary | 187          | -124 A      | 'Rev.' 25' | <b>VI</b>             | The 1st, Mercury's [first appearance] in the west in Libra   |   |
| Alm   | 233          | LBAT 1160   | Obv. 10    | <b>[VI]</b>           | The 1st, Mercury's first appearance in the west in 'x'   | n n   |

## Appendix I

|       | Year<br>(SE) | Text        |            |              |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------|--------------|-------------|------------|--------------|---|---|
| Diary | 187          | -124 B      | 'Obv.' 18' | <b>IX</b>    | Around the 21st, Mercury's first appearance in the west in Capricorn                                |   |
| Alm   | 233          | LBAT 1160   | Rev. 4     | <b>[IX]</b>  | The 21st, Mercury's first appearance in the west in Capricorn.                                      | n n   |
| Diary | 187          | -124 B      | 'Rev.' 7'  | <b>X</b>     | Around the 28th, Mercury's first appearance in the east in the end of Capricorn                     |   |
| Alm   | 233          | LBAT 1160   | Rev. 7     | <b>[X]</b>   | The 28th, Mercury' first appearance in the east in the beginning of Aquarius.                       | n n   |
| Diary | 188          | -123 A      | 'Obv. 11'  | <b>III</b>   | The 19th, Mercury's first appearance in the east in Gemini ... (ideal) first on the 16th            |   |
| Alm   | 234          | LBAT **1161 | Obv. 6     | <b>[III]</b> | [13th-23rd...] first appearance [...] Gemini.   | n n   |
| Diary | 188          | 123 A       | Rev.' 5    | <b>IV</b>    | [The x+]1st, Mercury's last appearance in the east in the end of Gemini                             |   |
| Alm   | 234          | LBAT **1167 | Obv. 7     | <b>[IV]</b>  | The 1st, Mercury's last appearance in the east in the end of Gemini.                                | n n   |
| Diary | 188          | 123 C       | Line 11'   | <b>V</b>     | Around the 10th, Mercury's [first appearance in the west in Virgo ...]                              |   |
| Alm   | 234          | LBAT **1167 | Obv. 9     | <b>[V]</b>   | The 10th, Mercury in the west in Virgo [...]  | n n   |
| GYT   | 190          | 86          | Obv. 20    | <b>II</b>    | Around the 6th, Mercury's first appearance in the west <sup>sic</sup> omitted                       |   |
| Alm   | 236          | LBAT 1174   | Obv. 3     | <b>II</b>    | [7th-14th] 'x' Mercury's first appearance in the east, omitted                                      | n n   |
| GYT   | 190          | 86          | Obv. 20-21 | <b>II</b>    | Around the 20th, Mercury's last appearance in the east, omitted                                     |   |
| Alm   | 236          | LBAT 1174   | Obv. 4     | <b>II</b>    | The 20th, Mercury's last appearance in the east, omitted  | n n   |
| Diary | 190          | -121        | 'Obv. 4'   | <b>III</b>   | Around the 17th, Mercury's [first appearance] in the west in Cancer ...                             |   |
| Alm   | 236          | LBAT 1174   | Obv. 5     | <b>III</b>   | The 15th, Mercury's first appearance in the west in Cancer.   | n n   |
| GYT   | 190          | 86          | Obv. 21    | <b>III</b>   | The 19th, Mercury's first appearance in the west in Cancer ... (ideal) first appearance on the 17th |   |
| Alm   | 236          | LBAT 1174   | Obv. 5     | <b>III</b>   | The 15th, Mercury's first appearance in the west in Cancer.   | n n   |

|     | Year<br>(SE) | Text      |            |             |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-----|--------------|-----------|------------|-------------|---|---|
| GYT | 190          | 86        | Obv. 22    | <b>IV</b>   | Around the 23rd, Mercury's last appearance in the west in Leo                                       |   |
| Alm | 236          | LBAT 1174 | Obv. 8-9   | <b>IV</b>   | The 23rd, Mercury's last appearance in the west in the end of Leo                                   | n n   |
| GYT | 190          | 86        | Obv. 22    | <b>V</b>    | The 24th, Mercury's first appearance in the east in Leo ... (ideal) first appearance on the 21st    |   |
| Alm | 236          | LBAT 1174 | Obv. 10    | <b>V</b>    | The 21st, Mercury's first appearance in the east in Leo.  | n n   |
| GYT | 190          | 86        | Obv. 23    | <b>VI</b>   | [last] appearance of Mercury in Virgo, when I watched from the 12th I did not see it                |   |
| Alm | 236          | LBAT 1174 | Obv. 11-12 | <b>VI</b>   | The 12th, Mercury's last appearance in the east in Virgo  | n n   |
| GYT | 190          | 86        | Obv. 23    | <b>VIII</b> | Around the 8th, Mercury's first appearance in the west in Sagittarius                               |   |
| Alm | 236          | LBAT 1174 | Rev. 1     | <b>VIII</b> | The 8th, Mercury's first appearance in the east in Sagittarius                                      | n n   |
| GYT | 190          | 86        | Obv. 23-24 | <b>VIII</b> | Around the 23rd, Mercury's last appearance in the west in Sagittarius                               |   |
| Alm | 236          | LBAT 1174 | Rev. 2     | <b>VIII</b> | The 23rd, Mercury's last appearance in the west in Sagittarius.                                     | n n   |
| GYT | 190          | 86        | Obv. 24    | <b>IX</b>   | Around the 7th, Mercury's first appearance in the east in Sagittarius                               |   |
| Alm | 236          | LBAT 1174 | Rev. 3     | <b>IX</b>   | The 7th, Mercury's first appearance in the east in Sagittarius.                                     | n n   |
| GYT | 190          | 86        | Obv. 24    | <b>X</b>    | Around the 13th, Mercury's last appearance in the east in Capricorn                                 |   |
| Alm | 236          | LBAT 1174 | Rev. 6     | <b>X</b>    | The 23rd, Mercury's last appearance in the east in Capricorn.                                       | n n   |
| GYT | 190          | 86        | Obv. 25    | <b>XI</b>   | The 24th, Mercury's first appearance in the west in Pisces ... (ideal) first appearance on the 23rd |   |
| Alm | 236          | LBAT 1174 | Rev. 8     | <b>XI</b>   | The 23rd, Mercury's [first appearance] in the east in Pisces.                                       | n n   |
| GYT | 190          | 86        | Obv. 26    | <b>XII</b>  | Around the 17th, Mercury's last appearance in the west in Aries                                     |   |
| Alm | 236          | LBAT 1174 | Rev. 9-10  | <b>XII</b>  | The 27th, Mercury's last appearance in the west in Aries  | n n   |

|              | Year<br>(SE) | Text                 |                             |                            |  | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|--------------|--------------|----------------------|-----------------------------|----------------------------|--|---|
| GYT<br>Alm   | 199<br>245   | 88<br>LBAT *1179-80  | 'Obv. 8'<br>Obv. 5-6        | <b>III</b><br><b>III</b>   | The 29th, Mercury's last appearance in the west in ...<br>The 22nd, Mercury's last appearance [in x in] Cancer.  | n n   |
| GYT<br>Alm   | 199<br>245   | 88<br>LBAT *1179-80  | 'Obv. 9'<br>Obv. 8          | <b>[IV]</b><br><b>IV</b>   | (ideal) first appearance in the east on the 22nd<br>The 22nd, Mercury's first appearance in the east in Cancer.  | n n   |
| GYT<br>Alm   | 199<br>245   | 88<br>LBAT *1179-80  | 'Obv. 10'-11'<br>Obv. 13-14 | <b>VII</b><br><b>VII</b>   | Around the 18th, [Mercury's last appearance] in the west ... [omitted]<br>The 15th, Mercury's last appearance in the west omitted  | n n   |
| GYT<br>Alm   | 199<br>245   | 88<br>LBAT *1179-80  | 'Obv. 11'<br>Rev. 15-16     | <b>VIII</b><br><b>VIII</b> | The 8th, Mercury's [first appearance] in the east in ... (ideal) first appearance on the 5th<br>'The 8th <sup>2</sup> Mercury's first appearance in the east in the end of Libra                               | n n   |
| GYT<br>Alm   | 199<br>245   | 88<br>LBAT *1179-80  | 'Obv. 13'<br>Rev. 20        | <b>X</b><br><b>X</b>       | The 22nd <sup>2</sup> Mercury's first appearance in the west in Aquarius... (ideal) first appearance on the 21st<br>'The 17th <sup>2</sup> Mercury's first appearance in the west in 'Aquarius'                | n n   |
| Diary<br>Alm | 200<br>246   | -111 A<br>LBAT *1181 | Obv.' 6<br>Obv. 3           | <b>I</b><br><b>II</b>      | The 10th, Mercury's first appearance [in the west in] Taurus ... [(ideal) first on the 8th ...]<br>The 8th <sup>2</sup> , Mercury's first appearance in the west in Taurus.                                    | y y   |
| Diary<br>Alm | 200<br>246   | -111 B<br>LBAT *1181 | 'Obv.' 4'<br>Obv. 5         | <b>II</b><br><b>III</b>    | Around the 15th, Mercury's [last appearance] in the west in the beginning of Ca[n]cer ...<br>The 15th, Mercury's last appearance in the west in Cancer.  | y y   |
| GYT<br>Alm   | 201<br>247   | 92<br>LBAT 1182      | Obv. 11<br>Obv. 1           | <b>I</b><br><b>I</b>       | The 4th, Mer[cury's] first appearance [...] (ideal) first appearance on the 3rd <sup>2</sup><br>The 2nd, 'Mercury <sup>2</sup> 's first appearance in the west in Taurus                                       | n n   |
| GYT<br>Alm   | 201<br>247   | 92<br>LBAT 1182      | Obv. 14<br>Obv. 6           | <b>[IV]</b><br><b>III</b>  | [The x]+1st, Mercury's last appearance in the east in the beginning of Gemini ... from the 28th of Month III when I watched [I did not see it...]<br>The 25th, Mercury's last appearance in the east in Gemini | n n   |

|               | Year<br>(SE) | Text         |            |               |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|---------------|--------------|--------------|------------|---------------|---|---|
| Diary         | 202          | -109 A       | 'Obv.' 18' | <b>[IX]</b>   | The 9th, Mercury's first appearance [in the west ...] (ideal) first on the 7th in Sagittarius.    |   |
| Alm           | 248          | LBAT 1183    | Rev. 3     | <b>[IX]</b>   | The 7th, 'Mercury's first appearance in the west in x <sup>1</sup>                                | n n   |
| Diary         | 251          | -60          | 'Obv. 5'   | <b>VIII</b>   | The 7th, Mercury's [last appearance] in the west in Scor[p]ius                                    |   |
| Alm           | 297          | LBAT 1187    | Obv. 9     | <b>[VIII]</b> | The 8th, Mercury in the east (error for west) in the end of Scorpio [...]                         | n n   |
| Diary         | 251          | -60          | Rev.' 4    | <b>VIII</b>   | Around the 23rd, Mercury's first appearance in the east in Scorp[us]                              |   |
| Alm           | 297          | LBAT 1187    | Obv. 10    | <b>[VIII]</b> | The 13th, [...] first appearance in the east in Scorpio   | n n   |
| Saturn events |              |              |            |               |   |   |
| Diary         | 48           | -263         | 'Obv.' 14' | <b>IX</b>     | The 18th, Saturn's acrony[chal rising]  |   |
| NSA           | 107          | LBAT 1016-18 | Rev. 3     | <b>X</b>      | The 13th, Saturn's acronychal rising.   | y y   |
| GYT           | 48           | 18           | 'Obv. 5'   | <b>IX</b>     | Around the 18th, Saturn's acronychal rising   |   |
| NSA           | 107          | LBAT 1016-18 | Rev. 3     | <b>X</b>      | The 13th, Saturn's acronychal rising.   | y y   |
| GYT           | 48           | 18           | 'Obv. 5'   | <b>XI</b>     | Night of the 10th first part, Saturn 1 finger [above $\delta$ Can]cri                             |   |
| NSA           | 107          | LBAT 1016-18 | Rev. 11    | <b>XII</b>    | 'x' Saturn 2 fingers above $\delta$ Cancr[us]   | y y   |
| Diary         | 57           | -254         | Rev.' 1    | <b>X</b>      | Night of the 1st last part Saturn 8 fingers above $\beta$ Scorpii                                 |   |
| NSA           | 116          | LBAT 1021    | Rev. 7     | <b>IX</b>     | Night of the 28th last part Saturn 8 fingers above $\beta$ Scorpii ...                            | n n   |
| Diary         | 74           | -237         | Rev.' 8-9  | <b>V</b>      | Night of the 6th ... last part Sat[urn] 3 fingers [... $\zeta$ Tau]ri                             |   |
| NSA           | 133          | MLC 1885     | Obv. 9     | <b>V</b>      | Night of the 3rd last part Saturn 6 fingers above $\zeta$ Tauri                                   | n n   |
| Diary         | 114          | -197 B       | 'Rev. 4'   | <b>XI</b>     | Around the 10th, when Saturn became stationary... $\frac{1}{2}$ cubit in front of $\alpha$ Librae |   |
| NSA           | 173          | LBAT 1039    | Rev. 16    | <b>XI</b>     | The 5th, Saturn stationary in Libra   | n n   |

|       | Year<br>(SE) | Text        |            |                         |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-------|--------------|-------------|------------|-------------------------|--|---|
| Diary | 129          | -182 A      | 'Obv.' 3'  | <b>I</b>                | The 23rd, Saturn's first app[earance] in the end of Pisces   |   |
| NSA   | 188          | LBAT 1051   | Obv. 3     | <b>I</b>                | The 14th, Saturn's first appearance in the beginning of Aries  | n n   |
| GYT   | 129          | 64          | 'Obv.' 8'  | <b>I</b>                | [The xth, Saturn's first appearance in Pisces]   |   |
| NSA   | 188          | LBAT 1051   | Obv. 3     | <b>I</b>                | The 14th, Saturn's first appearance in the beginning of Aries  | n n   |
| GYT   | 133          | 68          | 'Obv.' 23' | <b>[VII]</b>            | [... Saturn] 6 fingers above ζ Tauri   |   |
| NSA   | 192          | LBAT 1056   | Rev. 3     | <b>VII</b>              | [...] 21st last part Saturn 6 fingers above [ζ] Tauri <sup>?</sup>   | n n   |
| GYT   | 133          | 68          | 'Obv.' 23' | <b>VIII</b>             | The 11th, Saturn's acronychal rising   |   |
| NSA   | 192          | LBAT 1056   | Rev. 7     | <b>VIII</b>             | The 6th, Saturn's acronychal rising  | n n   |
| GYT   | 135          | 69          | Obv. 34    | <b>II</b>               | The 17th, Saturn's last appearance in Gemini   |   |
| NSA   | 194          | LBAT 1057   | Obv. 12    | <b>III</b>              | The 5th, Saturn 'xx' [...last appearance <sup>?</sup> ]  | y y   |
| GYT   | 135          | 69          | Obv. 35    | <b>III</b>              | The 21st, Saturn's first appearance in Gemini  |   |
| NSA   | 194          | LBAT 1057   | Obv. 19    | <b>IV</b>               | The 13th, Saturn's first appearance in Gemini.   | y y   |
| GYT   | 135          | 69          | LE 1       | <b>[IX<sup>?</sup>]</b> | Around the 11th, Saturn's acronychal rising  |   |
| NSA   | 194          | LBAT 1057   | Rev. 5     | <b>X</b>                | The 6th, Saturn's acronychal rising  | y y   |
| GYT   | 135          | 69          | LE 2       | <b>XI</b>               | Around the 11th Saturn became stationary to the west 6 fingers in front of α Geminorum...                                |   |
| NSA   | 194          | LBAT 1057   | Rev. 13    | <b>XII</b>              | The 10th, Saturn stationary in Gemini  | y y   |
| GYT   | 142          | 73          | Rev. 16    | <b>[II]</b>             | [The xth] when [Saturn became stationary to the west ... x+] <sup>1</sup> / <sub>2</sub> cubits in front of [γ Virginis] |   |
| NSA   | 201          | LBAT **1059 | Obv. 8     | <b>II</b>               | The 1st, Saturn stationary in Virgo  | n n   |

|              | Year<br>(SE) | Text                |                       |                           |   | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|--------------|--------------|---------------------|-----------------------|---------------------------|---|---|
| GYT<br>NSA   | 142<br>201   | 73<br>LBAT **1059   | Rev. 17<br>Obv. 16    | <b>IV</b><br><b>III</b>   | Night of the 12th first part, Saturn [...] fingers [below $\gamma$ Virginis]<br>Night of the 20th first part Saturn 6 fingers below $\gamma$ Virginis.                | n n   |
| GYT<br>NSA   | 142<br>201   | 73<br>LBAT **1059   | Rev. 17-18<br>Obv. 27 | <b>V</b><br><b>V</b>      | The 27th, Saturn's last appearance in Virgo: from the 23rd, when I watched, I did not see it.<br>The 14th, Saturn's last appearance in Virgo                          | n n   |
| GYT<br>NSA   | 142<br>201   | 73<br>LBAT **1059   | Rev. 18-19<br>Obv. 33 | <b>[VII]</b><br><b>VI</b> | [The xth, Saturn's] first appearance [in Virgo ...] (ideal) first on the 12th.<br>The 24th, Saturn's first appearance in Virgo  | n n   |
| GYT<br>NSA   | 142<br>201   | 73<br>LBAT **1059   | Rev. 19<br>Rev. 43    | <b>IX</b><br><b>VIII</b>  | Night of the 4[+xth last part Saturn x]+1 cubits [above $\alpha$ Virginis].<br>Night of the 12th last part Saturn 1 ½ cubits above $\alpha$ Virginis                  | n n   |
| GYT<br>NSA   | 142<br>201   | 73<br>LBAT **1059   | Rev. 19-20<br>Rev. 60 | <b>XI</b><br><b>XI</b>    | Around until the 7th <sup>?</sup> , when Saturn became stationary to the east ... [behind $\alpha$ Virginis]<br>The 2nd, Saturn stationary in the beginning of Libra. | n n   |
| GYT<br>Alm   | 142<br>201   | 73<br>LBAT 1151     | Rev. 18-19<br>Obv. 13 | <b>[VII]</b><br><b>VI</b> | [The xth, Saturn's] first appearance [in Virgo ...] (ideal) first on the 12th.<br>The 24th, Saturn's first appearance in Virgo.                                       | n n   |
| GYT<br>Alm   | 177<br>236   | 86<br>LBAT 1174     | Obv. 27<br>Obv. 1     | <b>II</b><br><b>I</b>     | Around the 4th, Saturn's acronychal rising<br>The 27th, Saturn's 'acronychal rising'  | n n   |
| GYT<br>Alm   | 177<br>236   | 86<br>LBAT 1174     | Obv. 27<br>Obv. 7     | <b>IV</b><br><b>IV</b>    | Until the 8th, when Saturn became stationary to the west...<br>The 1st, Saturn stationary in Scorpio.   | n n   |
| Diary<br>Alm | 177<br>236   | -134 B<br>LBAT 1174 | Obv.' 19<br>Obv. 13   | <b>VIII</b><br><b>VII</b> | The 4th, setting of Saturn in Scorpius ... from the 1st not seen<br>The 21st, Saturn's last appearance in Scorpio   | n n   |

|                 | Year<br>(SE) | Text                   |                     |                            |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-----------------|--------------|------------------------|---------------------|----------------------------|--|---|
| GYT<br>Alm      | 177<br>236   | 86<br>LBAT 1174        | Obv. 28<br>Obv. 13  | <b>VIII</b><br><b>VII</b>  | The 4th, Saturn's last appearance in Scorpio, from the 2nd when I watched I did not see it<br>The 21st, Saturn's last appearance in Scorpio    | n n   |
| GYT<br>Alm      | 178<br>236   | 86<br>LBAT 1174        | Obv. 30<br>Rev. 10  | <b>I</b><br><b>XII</b>     | Around the 6th, when Saturn became stationary to the east...<br>The 29th, Saturn 'stationary' <sup>1</sup> in Sagittarius                      | n n   |
| GYT<br>Alm      | 186<br>245   | 88<br>LBAT *1079-80    | 'Obv. 16'<br>Obv. 7 | <b>IV</b><br><b>IV</b>     | Around until the 14th, Saturn became stationary to the east in Pisces<br>The 7th, Saturn 'stationary' <sup>1</sup> [in] P[isce]s               | n n   |
| Mars' phenomena |              |                        |                     |                            |  |   |
| Diary<br>NSA    | 22<br>101    | -289<br>BCMA 1846-1982 | Rev.' 5<br>Obv. 14  | <b>IV</b><br><b>IV</b>     | The 8th, Mars' [first appearance] in the east in Cancer<br>The 1st, Mars' last (error for first <sup>2</sup> ) appearance in the end of Gemini | n n   |
| GYT<br>NSA      | 26<br>105    | 14<br>LBAT *1011       | 'Obv. 3'<br>Obv. 6  | <b>III</b><br><b>II</b>    | The 23rd, Mars' last appearance in Cancer<br>The 23rd, Mars' last appearance in Cancer   | y y   |
| Diary<br>NSA    | 27<br>106    | -284<br>BM 41022+      | Obv.' 6'<br>Rev. 2  | <b>VII</b><br><b>VII</b>   | Around the 15th, when Mars became stationary to the west ... 2/3 cubit below $\eta$ Piscium<br>15th, Mars stationary <sup>2</sup> in Pisces    | n n   |
| GYT<br>Alm      | 50<br>129    | 27<br>LBAT 1123        | Obv. 33<br>Rev. 1   | <b>XI</b><br><b>XI</b>     | The 20th <sup>2</sup> , Mars' acronychal rising<br>The 14th, Mars' acronychal rising.  | n n   |
| Diary<br>Alm    | 50<br>129    | -261 B<br>LBAT 1123    | 'Rev.' 5'<br>Rev. 3 | <b>XII</b><br><b>[XII]</b> | Around the 23 <sup>rd</sup> , when Mars became stationary to the west behind $\varrho$ Le]onis<br>[23-28th...] Mars stationary in Leo          | n n   |
| GYT<br>Alm      | 50<br>129    | 27<br>LBAT 1123        | Obv. 33<br>Rev. 3   | <b>XII</b><br><b>[XII]</b> | Until the 22nd, when Mars [became stationary] to the west...<br>[23-28th...] Mars stationary in Leo  | n n   |

## Appendix I



|       | Year<br>(SE) | Text           |               |             |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------|--------------|----------------|---------------|-------------|---|---|
| Diary | 77           | -234 B         | Obv.' 27      | <b>IX</b>   | The 8th, Mars' first appearance in Scorpius   |   |
| NSA   | 156          | LBAT *1032     | Rev. 4        | <b>IX</b>   | The 4th last part Mars' first appearance in the east in Scorpio.                                      | n n   |
| Diary | 104          | -207 A         | Obv.' 28      | <b>II</b>   | Around the 20th, when Mars became stationary to the east ... 2 cubits in front of $\gamma$ Capricorni |   |
| Alm   | 183          | LBAT 1137-8    | Obv. 5        | <b>II</b>   | The 20th, Mars stationary in Capricorn  | n n   |
| GYT   | 115          | 69             | LE 3          | <b>XII</b>  | Around the 8th, Mars' last appearance in the end of Pisces  |   |
| NSA   | 194          | LBAT 1057      | Rev. 12       | <b>XII</b>  | The 8th, Mars' last appearance in the end of Pisces.  | n n   |
| Diary | 122          | -189 B         | 'Obv.' 14'    | <b>VII</b>  | 1st, Mars [first appearance in the beginning of Libra]  |   |
| NSA   | 201          | LBAT **1059    | Rev. 36       | <b>VII</b>  | The 8th, Mars' first appearance in Libra  | n n   |
| Diary | 122          | -189 A         | 'Obv.' 16'    | <b>III</b>  | [11th <sup>2</sup> ] Mars' last appearance in Cancer  |   |
| Alm   | 201          | LBAT 1151      | Obv. 8        | <b>III</b>  | “The 22nd, Mars' last appearance in Cancer.   | n n   |
| Diary | 122          | -189 B         | 'Obv.' 14'    | <b>VII</b>  | The 1st, Mars' [first appearance in the beginning of Libra]   |   |
| Alm   | 201          | LBAT 1151      | Obv. 14       | <b>VII</b>  | The 8th, Mars' 'first appearance <sup>2</sup> in Leo $\zeta$  | n n   |
| GYT   | 157          | 86             | Obv. 38       | <b>[IX]</b> | Around the 2 <sup>nd</sup> , Mars' acronychal rising  |   |
| Alm   | 236          | LBAT 1174      | Rev. 3        | <b>IX</b>   | The 6th, 'Mars' acronychal rising <sup>1</sup>  | n n   |
| GYT   | 166          | 88             | 'Obv. 18'-19' | <b>I</b>    | Around until the 10th, Mars became stationary to the east   |   |
| Alm   | 245          | LBAT **1179-80 | Obv. 2        | <b>I</b>    | [2]7th Mars 'stationary <sup>1</sup> in Sagittarius   | n n   |
| GYT   | 166          | 88             | 'Obv. 19'     | <b>II</b>   | Around the 20th, Mars' acronychal rising.   |   |
| Alm   | 245          | LBAT **1179-80 | Obv. 4        | <b>II</b>   | The 29th, Mars' acronychal rising.  | n n   |

|                   | Year<br>(SE) | Text                 |                         |  |   | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------------------|--------------|----------------------|-------------------------|--|---|---|
| GYT<br>Alm        | 166<br>245   | 88<br>LBAT **1179-80 | 'Obv. 19'-20'<br>Obv. 7 | <b>III</b><br><b>IV</b>                | Until the 25th, Mars became stationary to the west<br>The 3rd, Mars stationary in the beginning of Sagittarius.                         | n n   |
| Diary<br>Alm      | 167<br>246   | -144<br>LBAT *1181   | 'Obv. 13'<br>Obv. 11    | <b>VI</b><br><b>[VI]</b>               | Around the 13th, Mars' first appearance in Virgo<br>'x' Mars' first appearance in Leo.  | n n   |
| Diary<br>Alm      | 218<br>297   | -93 A<br>LBAT 1187   | Rev.' 10<br>Obv. 2      | <b>IV</b><br><b>[IV]</b>               | Around the 17th, Mars' last appearance in Leo<br>The 23rd <sup>2</sup> Mars' last appearance in Leo.                                    | n n   |
| Diary<br>Alm      | 226<br>305   | -85 C<br>LBAT 1195   | 'Rev. 19'<br>Rev. 10    | <b>XII</b><br><b>[XII<sub>2</sub>]</b> | Around the 27th, Mars [last appearance] in Aries<br>[1st-3rd] 'x' last appearance in Aries.   | n n   |
| Mars' NS passages |              |                      |                         |  |   |   |
| GYT<br>NSA        | 49<br>96     | 10<br>LBAT **1007    | 'Rev. 3'-4'<br>Obv. 4   | <b>I</b><br><b>I</b>                   | Night of the 5th first part Mars, 2 ½ cubits below ε Leonis<br>'Night of the' 21st first part Mars 3 cubits below <sup>2</sup> ε Leonis | n n   |
| GYT<br>NSA        | 49<br>96     | 10<br>LBAT **1007    | 'Rev. 4'<br>Obv. 6      | <b>I</b><br><b>II</b>                  | Night of the 25th first part Mars 14 fingers above α Leonis<br>Night of the 11th first part Mars 14 fingers above α Leonis              | n n   |
| GYT<br>NSA        | 49<br>96     | 10<br>LBAT **1007    | 'Rev. 4'-5'<br>Obv. 7   | <b>II</b><br><b>II</b>                 | Night of the 9th first part Mars ½ cubit above ρ Leonis<br>Night of the 25th first part Mars [...] above ρ [Leonis]                     | n n   |
| GYT<br>NSA        | 49<br>96     | 10<br>LBAT **1007    | 'Rev. 5'<br>Obv. 9      | <b>II</b><br><b>III</b>                | Night of the 28th first part Mars 4 cubits below θ Leonis<br>Night of the 14th first part 'Mars' 4 'cubits' below θ Leonis              | n n   |
| GYT<br>NSA        | 49<br>96     | 10<br>LBAT **1007    | 'Rev. 6'<br>Obv. 11     | <b>[III]</b><br><b>IV</b>              | [...] first part Mars 1 finger above β Virginis, it came close<br>x first part Mars 1 finger above β Virginis                           | n n   |

|       | Year<br>(SE) | Text         |             |            |  | Month shift-      |                       |
|-------|--------------|--------------|-------------|------------|--|-------------------|-----------------------|
|       |              |              |             |            |  | Seen <sup>?</sup> | Expected <sup>?</sup> |
| GYT   | 49           | 10           | 'Rev. 7'    | <b>IV</b>  | Night of the 29th first part Mars 1 cubit above $\alpha$ Virginis      |                   |                       |
| NSA   | 96           | LBAT **1007  | Obv. 11     | <b>IV</b>  | x first part Mars 1 finger above $\beta$ Virginis                      | n                 | n                     |
| GYT   | 49           | 10           | 'Rev. 7'-8' | <b>V</b>   | Night of the 30th, 8 fingers [... $\alpha$ Lib]rae                     |                   |                       |
| NSA   | 96           | LBAT 1008    | Obv. 14     | <b>VI</b>  | Night of the 16th first part Mars 8 fingers below $\alpha$ Librae.     | n                 | n                     |
| Diary | 57           | -254         | Rev.' 1     | <b>X</b>   | Night of the 3rd first part Mars 1 5/6 cubits below $\eta$ Piscium     |                   |                       |
| NSA   | 104          | LBAT 1010    | Rev. 10     | <b>X</b>   | Night of the 19th first part Mars [...] below [ $\eta$ Piscium ]       | n                 | n                     |
| GYT   | 58           | 14           | 'Obv. 4'    | <b>I</b>   | Night of the 19th first part Mars [...] above $\eta$ Geminorum         |                   |                       |
| NSA   | 105          | LBAT *1011   | Obv. 1      | <b>I</b>   | Night of the 5th first part Mars 20 fingers above $\eta$ Geminorum     | y                 | y                     |
| GYT   | 58           | 14           | 'Obv. 5'    | <b>I</b>   | [...] Mars 20 fingers above $\mu$ Geminorum                            |                   |                       |
| NSA   | 105          | LBAT *1011   | Obv. 1      | <b>I</b>   | Night of the 9th first part Mars 20 fingers above $\mu$ Geminorum      | y                 | y                     |
| GYT   | 58           | 14           | 'Obv. 5'    | <b>II</b>  | Night of the 1st first part Mars [...] above $\gamma$ Geminorum        |                   |                       |
| NSA   | 105          | LBAT *1011   | Obv. 2      | <b>I</b>   | Night of the 18th first part Mars 3 cubits above $\gamma$ Geminorum.   | y                 | y                     |
| GYT   | 58           | 14           | 'Obv. 6'    | <b>II</b>  | [Night of the xth first] part Mars 3 ½ cubits below $\alpha$ Geminorum |                   |                       |
| NSA   | 105          | LBAT *1011   | Obv. 4      | <b>II</b>  | [Night of the 1st] first part Mars 3 ½ cubits below $\alpha$ Geminorum | y                 | y                     |
| GYT   | 58           | 14           | 'Obv. 6'    | <b>II</b>  | Night of the 23rd first part Mars 2 ½ cubits below $\beta$ Geminorum   |                   |                       |
| NSA   | 105          | LBAT *1011   | Obv. 5      | <b>II</b>  | Night of the 9th first part Mars [...] below $\beta$ Geminorum         | y                 | y                     |
| GYT   | 60           | 18           | Rev.' 3     | <b>[I]</b> | Night of the 17th first part Mars 2 [cubits] below $\alpha$ Geminorum  |                   |                       |
| NSA   | 107          | LBAT 1016-18 | Obv. 3      | <b>II</b>  | 3rd first part Mars 3 ½ cubits below $\alpha$ Geminorum.               | n                 | n                     |
| Diary | 60           | -251         | 'Rev. 4'-5' | <b>XII</b> | Night of the 5th [last part] Mars 5/6 cubit above $\delta$ Capricorni  |                   |                       |
| NSA   | 107          | LBAT 1016-18 | Rev. 1 3-14 | <b>XII</b> | Night of the 22nd last part Mars [...] above [ $\delta$ Capricorni]    | n                 | n                     |

## Appendix I

|     | Year<br>(SE) | Text         |             |              |  | Month shift-<br>Seen <sup>?</sup> Expected <sup>?</sup> |
|-----|--------------|--------------|-------------|--------------|--|---|
| GYT | 60           | 16           | 'Rev.' 2'   | <b>XII</b>   | Night of the 3rd, last [part Mars .. above $\delta$ Capricorni]              |   |
| NSA | 107          | LBAT 1016-18 | Rev. 1 3-14 | <b>XII</b>   | Night of the 22nd last part Mars [...] above [ $\delta$ Capricorni]          | n n   |
| GYT | 147          | 69           | LE 4        | <b>II</b>    | Night of the 20th first part Mars 1 cubit below $\gamma$ Virginis            |   |
| NSA | 194          | LBAT 1057    | Obv. 13     | <b>III</b>   | [5th-9th... Mars] 1 cubit below $\gamma$ Virginis                            | n n   |
| GYT | 147          | 69           | Le 4-5      | <b>III</b>   | Night of the 15th [first] part Mars 1 cubit above $\alpha$ Virginis          |   |
| NSA | 194          | LBAT 1057    | Obv. 17     | <b>IV</b>    | Night of the 2nd first part Mars 2 cubits above $\alpha$ Virginis            | n n   |
| GYT | 147          | 69           | Rev. 2      | <b>VIII</b>  | Night of the 16th first part Mars 2 cubits below $\beta$ Capricorni          |   |
| NSA | 194          | LBAT 1057    | Rev. 2      | <b>IX</b>    | Night of the <sup>?</sup> 2nd first part Mars [...] below $\beta$ Capricorni | n n   |
| GYT | 154          | 73           | Rev. 36'    | <b>I</b>     | [...Mars] 4 cubits [above] $\gamma$ Geminorum                                |   |
| NSA | 201          | LBAT **1059  | Obv. 3      | <b>I</b>     | Night of the 9th first part Mars 4 cubits above $\gamma$ Geminorum           | n n   |
| GYT | 154          | 73           | Rev. 37'    | <b>I</b>     | [...] Mars 3 ½ cubits below $\alpha$ Geminorum                               |   |
| NSA | 201          | LBAT **1059  | Obv. 6      | <b>I</b>     | Night of the 28th first part Mars 3 ½ cubits below $\alpha$ Geminorum.       | n n   |
| GYT | 154          | 73           | Rev. 37'    | <b>I</b>     | Night of the 21st first part Mars [...]                                      |   |
| NSA | 201          | LBAT **1059  | Obv. 10     | <b>II</b>    | Night of the 8th first part Mars 2 ½ cubits below $\beta$ Geminorum          | n n   |
| GYT | 154          | 73           | Rev. 38'    | <b>II</b>    | [...] Mars ½ cubit above $\delta$ Cancrī                                     |   |
| NSA | 201          | LBAT **1059  | Obv. 14     | <b>III</b>   | Night of the 2nd first part Mars ½ cubits above $\delta$ Cancrī              | n n   |
| GYT | 154          | 73           | Rev. 39'    | <b>[VII]</b> | [Night of the xth] last part Mars 8 fingers below $\alpha$ Librae            |   |
| NSA | 201          | LBAT **1059  | Rev. 42     | <b>VIII</b>  | Night of the 2nd last part Mars 8 fingers below $\alpha$ Librae.             | n n   |

|       | Year<br>(SE) | Text        |              |               |  | Month shift-<br>Seen <sup>2</sup> Expected <sup>2</sup> |
|-------|--------------|-------------|--------------|---------------|--|---|
| GYT   | 154          | 73          | Rev. 39'-40' | <b>[VII]</b>  | Night of the 23rd last part Mars [... below $\beta$ Librae]                      |   |
| NSA   | 201          | LBAT **1059 | Rev. 42      | <b>VIII</b>   | Night of the 9th last part Mars 3 ½ cubits below $\beta$ Librae                  | n n   |
| GYT   | 154          | 73          | Rev. 40'     | <b>[VIII]</b> | [Night of the xth last part Mars] 8 fingers below $\beta$ Scorpii                |   |
| NSA   | 201          | LBAT **1059 | Rev. 44-46   | <b>VIII</b>   | Night of the 29th last part of the night Mars 8 fingers below $\beta$ Scorpii.   | n n   |
| GYT   | 154          | 73          | Rev. 40'-41' | <b>[VIII]</b> | Night of the 23rd last part Mars [... above $\alpha$ Scorpii]                    |   |
| NSA   | 201          | LBAT **1059 | Rev. 48      | <b>IX</b>     | Night of the 9th last part Mars 2 ½ cubits above $\alpha$ Scorpii.               | n n   |
| GYT   | 154          | 73          | Rev. 41'     | <b>[IX]</b>   | [Night of the xth last part Mars] ½ cubit [above $\theta$ ] Ophiuchi             |   |
| NSA   | 201          | LBAT **1059 | Rev. 50      | <b>IX</b>     | Night of the 25th last part Mars ½ cubit above $\theta$ Ophiuchi                 | n n   |
| GYT   | 154          | 73          | Rev. 41'     | <b>XI</b>     | Night of the 6th last part Mars 2 ½ cubits below $\beta$ Capricorni              |   |
| NSA   | 201          | LBAT **1059 | Rev. 61      | <b>XI</b>     | Night of the 22nd last part Mars 2 ½ cubits below $\beta$ Capricorni             | n n   |
| GYT   | 154          | 73          | Rev. 42'     | <b>[XII]</b>  | [Night of the x+]1st last part Mars ½ cubit above $\delta$ Capricorni            |   |
| NSA   | 201          | LBAT **1059 | Rev. 68      | <b>XII</b>    | Night of the 17th last part Mars ½ cubit above $\delta$ Capricorni               | n n   |
| Diary | 156          | -155 A      | Obv. 5       | <b>IV</b>     | Night of the 18th first part Mars 4 ½ cubits below $\theta$ Leonis               |   |
| NSA   | 203          | LBAT 1060   | Obv. 5       | <b>III</b>    | Night of the 30th first part Mars $\Gamma$ x $\zeta$ [...] below $\theta$ Leonis | y y   |

*Appendix J: a summary of the remarks found in the Goal-Year Texts concerning intercalary months*

| Goal year | Jupiter (71)                             | Jupiter (83)   | Venus (8)  | Mercury (46)                              | Saturn (59)                              | Mars (79)                                 | Mars (47)   |
|-----------|--|--|--|---|--|---|---|
| 79        |  |  |  |   |  |   | "Year 31 Month XII <sub>2</sub> ,<br>night of the 25th" |
| 91        |  |  | "Year 84 Month I,<br>around the 4th"                                     | "Month XII was<br>intercalary"            |  |   | "Year 45 Month I,<br>night of the 3rd"                  |
| 94        |  |  |  |   |  | "Month XII was<br>intercalary"            | "Year 46 Month XII,<br>night of the 24th"               |
| 95        |  |  | "Month I, night of<br>the 2nd"   |   |  |   |   |
| 96        |  |  | "Month XII was<br>intercalary"   |   |  |   |   |
| 97        | "Month XII was<br>intercalary"           |  |  |   | "[Year 37], Month VI<br>was intercalary" |   |   |
| 106       | "Year 34: Month XII<br>was intercalary"  | "Month XII was<br>intercalary"   |  |   |  | "[Year 26: Month XII<br>was] intercalary" | "[Year 58: Month XII<br>was intercalary]"               |
| 107       |  |  | "Month XII was<br>intercalary"<br>"Year 100, Month I,<br>around the 1st" |   |  |   |   |
| 118       | "Month XII was<br>intercalary"           | "Year 34 Month XII <sub>2</sub><br>night of the 22nd"<br>"Year 36 Month I<br>night of the 1st" | "Month XII was<br>intercalary"   | "Month XII was<br>intercalary"            | "Year 58: Month XII<br>was intercalary"  |   | "Year 70, Month XII<br>night of the 21st"               |
| 122       | "Year 50, Month XII<br>was intercalary." |  | "[Year 113, Month VI<br>was inter]calary."                               | "[Year 75], Month VI<br>was intercalary." |  |   |   |
| 124       |  |  |  | "Year 77: Month XII<br>was intercalary."  |  |   |   |

| Goal year | Jupiter (71)                | Jupiter (83)  | Venus (8)                              | Mercury (46)   | Saturn (59)  | Mars (79)                   | Mars (47)   |
|-----------|-----------------------------|---|--|--|--|-----------------------------|---|
| 129       |                             |   |  |  | "[Year 69, Month XII <sub>2</sub> ...] (ideal) first on the 24th." |                             |   |
| 131       |                             |   |  | "Month XII was intercalary"  |  |                             |   |
| 135       | "Month XII was intercalary" |   |  |  |  |                             |   |
| 139       |                             | "Month VI was intercalary"                          |  |  |  |                             |   |
| 140       |                             | "[Year 56, Month VI] was intercalary."              |  |  | "Year 80, Month XII <sub>2</sub> until the 25th"                   | "Month XII was intercalary" |   |
| 142       |                             |   | "[Year] 135, Month I night of the 2nd" |  | "Month XII [was intercalary]"                                      |                             |   |
| 155       |                             |   | "Year 148, Month I the 6th, "          |  |  |                             |   |
| 160       |                             | "Month XII was intercalary"                         | "Year 153 ..."                         |  |  |                             |   |
| 167       |                             | "Year 83, Month XII <sub>2</sub> night of the 15th" |  |  |  |                             |   |
| 168       |                             |   |  | "Year 123 [Month I the xth ...] (ideal) 1st on 26th of XII"<br>alt: Year 123 Month I the 1st |  |                             |   |
| 170       |                             | "Month XII was intercalary"                         |  |  |  |                             |   |
| 171       |                             |   |  |  |  |                             | "[Year 123] Month XII <sub>2</sub> night of the 24th" |
| 175       |                             | "Year 91: Month XII                                 |  |  | "[Year 115] Month XII <sub>2</sub> ,                               |                             |   |

| Goal year | Jupiter (71)                   | Jupiter (83)   | Venus (8)                                  | Mercury (46)     | Saturn (59)                                | Mars (79)                      | Mars (47)                                    |
|-----------|--------------------------------|--|--|------------------|--|--------------------------------|--|
| 177       |                                | was intercalary"<br>"Month VI was<br>intercalary"          |  |                  | the 29th"                                  |                                |  |
| 185       |                                |  |  | "[Year 138 ...]" |  |                                |  |
| 186       |                                |  | "Year 179 [Month I<br>night of the x]+1st" |                  |  |                                |  |
| 194       | "Month XII was<br>intercalary" | "Year 110: [Month<br>XII was intercalary.]"                |  |                  | "Year 134: Month XII<br>was intercalary"   | "Month XII was<br>intercalary" |  |
| 202       |                                | "Year 118, Month<br>XII <sub>2</sub> night of the<br>20th" | "Year 195 Month I<br>night of the 2nd"     |                  | "[Year 1]42: Month<br>XII was intercalary" |                                | "Year 156 Month I<br>night of the 12th"      |
| 205       | "Month XII was<br>intercalary" | "[Year 1]21, Month<br>XII was intercalary"                 |  |                  |  |                                |  |
| 211       |                                |  |  |                  |  | "Month VI was<br>intercalary"  |  |
| 236       |                                |  |  |                  | "Year 178, Month I<br>around the 6th"      |                                |  |
| 247       |                                |  |  |                  |  |                                | "[Year 1]99, Month<br>XII [was intercalary]" |



***Appendix K: a summary of records of Mercury's Greek-letter phenomena from the non-mathematical texts***

**Appendix K1: Mercury phenomena from the Astronomical Diaries (ADART Vols. I-III)**

| Diary No. | Line          | Record           |                    |  | Tropical longitude | Latitude |
|-----------|---------------|------------------|--------------------|--|--------------------|----------|
| -463      | Obv. 2'       | V                | [Around] the 19    | (Mercury's) first appearance (in the east)   | 133.51             | -0.524   |
| -463      | Obv. 7'       | VI               | Around 12 or 13    | Mercury's [last] appearance in the east in Virgo   | 161.966            | 1.769    |
| -418A     | Obv.' 5       | I                | 29                 | Mercury's last appearance in the west in Taurus.   | 44.585             | 1.515    |
| -418A     | Obv.' 18      | IV               | Around the 21      | Mercury's first appearance in the west in Leo  | 119.21             | 1.459    |
| -418A     | 'Rev. 5'      | XII              | 29                 | Mercury's [first appearance] in the west [in Aries].   | 5.329              | 1.465    |
| -418A     | 'Rev. 11'-12' | XII <sub>2</sub> | Around the 23      | Mercury's last appearance in the west in front of η Tauri.   | 24.871             | 2.229    |
| -384      | 'Obv. 5'      | IX               | 10                 | Mercury's [first appearance] in the east in Sagittarius [...]  | 237.392            | 3.165    |
| -380B     | 'Obv.' 5'     | X                | 20                 | Mercury's last appearance in the west in Capricorn   | 294.911            | 2.136    |
| -378      | 'Obv.' 9'     | VIII             | 22                 | Mercury's first appearance in the east in Sagittarius  | 249.378            | -2.226   |
| -375 B    | 'Obv. 10'     | X                | 26-30              | [... Mercury's first appearance] in the west] 8 fingers above Jupiter, 4 fingers back to the west                            | 307.739            | -0.571   |
| -375 B    | Rev.' 3       | XI               | 14                 | Mercury's last appearance in the west in Aquarius; I did not watch   | 285.33             | 1.009    |
| -373 B    | 'Obv.' 10'    | VII              | 27 or 28           | Mercury's last appearance <in the east> in Scorpio   | 201.863            | 0.802    |
| -373 B    | 'Rev.' 3'     | XI               | 21-26              | [... Mer]cury's last appearance in the east in Aquarius  | 303.125            | -1.959   |
| -373 B    | 'Rev. 15'     | XII              | 22-30              | [...] Mercury's first appearance in the west in Aries [...]  | 358.227            | -0.271   |
| -372 A    | Col. I 4      | I <sup>?</sup>   | 4                  | Mercury's [first appearance] in the west, 1 cubit 6 fingers above Jupiter  | 22.321             | 1.814    |
| -372 C    | 'Rev.' 8'     | IV               | 26                 | Mercury's first appearance in the west in Leo; (ideal) first appearance around the 19th.                                     | 129.955            | 0.912    |
| -370      | 'Obv.' 1'-2'  | IV               | 15                 | [... Mercury's] last appearance [in the west] in Leo   | 132.699            | -3.131   |
| -366 A    | Col. I 19'    | I                | Around the 22      | Mercury's last appearance behind the Chariot   | 56.768             | -0.95    |
| -366 B    | 'Obv. 38'     | IV <sup>?</sup>  | 10                 | Mercury's first appearance in the west in Leo, 3 cubits in front of Venus to the west...(ideal) first appearance on the 8th. | 135.312            | 0.908    |
| -346      | Obv. 10       | IX               | 21                 | Mercury's last appearance in the west in Capricorn   | 274.56             | 2.396    |
| -346      | Obv. 17       | IX               | 29                 | [...] rising (of Mercury) to sunrise: 20°; (ideal) first appearance on the 29th of month IX                                  | 264.881            | 3.625    |
| -346      | Rev. 6        | XI               | [13]               | [ Mercury's] last appearance in [the ea]st in Aquarius   | 300.156            | -2.006   |
| -346      | Rev. 25-26    | XII              | [17 <sup>?</sup> ] | 26 Mercury's first appearance in the west in Aries; sunset to setting of Mercury: 14°.                                       | 4.684              | 0.926    |
| -343      | 'Rev.' 19'    | XII              | 21                 | [... Mercury's first appearance in the west in Pisces ....] (ideal) first appearance [on] the 21st.                          | 326.398            | -1.136   |

| Diary No. | Line       | Record           |                    |   | Tropical longitude | Latitude |
|-----------|------------|------------------|--------------------|---|--------------------|----------|
| -332 A    | Obv.' 5    | V                | 10                 | Mercury's [last appearance] in the west in Virgo  | 157.479            | -3.343   |
| -329 B    | 'Rev. 3'   | XII <sub>2</sub> | 1 to 4             | Mercury's first appearance in the east in Pisces [...]  | 332.699            | -2.512   |
| -328      | Obv.' 8    | V                | 21                 | Mercury's [first] appearance in the west, omitted [...]   | 179.596            | -1.516   |
| -328      | Obv.' 27   | VII              | 4                  | Mercury's first appearance in the east in Libra   | 184.224            | 1.97     |
| -328      | 'Rev. 3'   | VIII             | 1 to 4             | [Mercury's] last appearance in the east in Scorpius   | 218.116            | 0.39     |
| -324 B    | 'Obv. 16'  | III              | 3                  | Mercury's first appearance in the west in Cancer;   | 80.839             | 1.867    |
| -324 B    | Rev.' 5    | IV               | 15                 | Mercury's last appearance in the west in Leo.   | 133.705            | -3.105   |
| -322 A    | 'Obv.' 11' | I <sup>2</sup>   | 22-30              | [... Mer]cury's [first appearance] in the west in Gemini [...]  | 49.202             | 1.536    |
| -322 D    | Obv. 24    | X                | 4                  | Mercury's first appearance in the west in Aquarius,   | 298.627            | -1.128   |
| -322 D    | Obv. 35    | X                | 23                 | Mercury's last appearance in the west in Aquarius   | 314.659            | 3.239    |
| -322 D    | Rev. 2     | XI               | 11                 | Mercury's first appearance in the east in Aquarius  | 301.482            | 2.149    |
| -322 D    | Rev. 25    | XII              | [12]               | Mercury's last appearance in the east in Pisces   | 327.876            | -2.424   |
| -321      | Obv.' 11   | I                | 20                 | Mercury's first appearance in the west in "Bull of Heaven"  | 39.265             | 1.609    |
| -321      | 'Rev. 17'  | VI               | 8                  | Mercury's first appearance in the east (error for: west) in Virgo (error for: Libra);                                 | 182.433            | -2.28    |
| -309      | 'Rev. 3'   | VIII             | 21                 | Mercury's [last appearance] in the east [in Sagittarius?]   | 236.667            | -0.46    |
| -308      | Obv.' 11   | I                | [19 <sup>2</sup> ] | [Mer]cury's first appearance in the west in "Bull of Heaven"; ... (ideal) first appearance on the 16th <sup>2</sup> . | 48.102             | 1.986    |
| -308      | Rev. 8'    | VI               | 3                  | Mercury's first appearance in the west in Libra; ... (ideal) first appearance on the 1st                              | 182.725            | -2.099   |
| -308      | Rev. 10'   | VI               | 11 <sup>2</sup>    | Mercury's last appearance in the west in Libra  | 191.188            | -2.9     |
| -307 B    | Line 3'    | IV               | 7                  | [last appearance] of Mercury in the east in Gemini; [omitted. ....]   | 85.95              | 0.911    |
| -294      | 'Obv.' 8'  | II               | 6                  | Mer]cury's last appearance in the west in Gemini ....]  | 64.093             | 0.789    |
| -291 A    | 'Obv.' 3'  | I                | 25 <sup>2</sup>    | Mercury's first appearance in the east, omitted   | 6.992              | -3.169   |
| -291 B    | 'Obv. 6'   | II               | 17                 | [Mercury's last appearance in the east, omitted. ]  | 40.889             | -0.518   |
| -291 B    | 'Obv. 15'  | III              | [8]                | [Mer]cury's first appearance in the west in Gemini  | 82.452             | 1.909    |
| -291 B    | Rev.' 7    | IV               | 22                 | Mercury's last appearance [in the wes]t in Leo.   | 132.385            | -3.879   |
| -291 B    | Rev.' 17   | V                | 15-16              | [Mer]cury's first appearance in the east in Leo.  | 118.839            | -1.384   |
| -289      | 'Obv. 19'  | III              | 12                 | Mercury's last appearance in the west in Cancer   | 94.367             | -3.792   |
| -289      | Rev.' 4    | IV               | 7                  | Mer]cury's first appearance in the east in Cancer... [(ideal) first appearance] on the 5th                            | 87.127             | -1.901   |
| -288      | Obv.' 5    | VII              | 17                 | Mercury's first appearance in the east in Libra   | 176.124            | 1.554    |
| -288      | 'Rev. 6'   | XII <sub>2</sub> | 16                 | [... Mercury's first appearance in the west in Aries, .... ] (ideal) first appearance on the 13th                     | 22.672             | 1.293    |

| Diary No. | Line       | Record           |                    |   | Tropical longitude | Latitude |
|-----------|------------|------------------|--------------------|---|--------------------|----------|
| -284      | Obv.' 7'   | VII              | 15                 | [Mercury's] first appearance [in the west ....], omitted.   | 227.637            | -2.576   |
| -284      | Obv. 13'   | VII              | Around the 25      | Mercury's last appearance in the west .... was omitted  | 233.012            | -1.478   |
| -284      | Obv. 24'   | VIII             | [14 <sup>2</sup> ] | Mercury's first appearance <sup>2</sup> in the east in Scorpius, 3 ½ cubits above a                   | 216.835            | 2.891    |
| -284      | 'Rev.' 16' | X                | [25 - 27]          | Mercury's [first appearance] in the west [....]   | 318.043            | -0.774   |
| -284      | 'Rev.' 28' | XI               | 18                 | Mercury's last appearance in the west in Pisces   | 340.424            | 3.551    |
| -283 A    | Obv. 4     | VII              | 27                 | Mercury's last appearance in the west omitted [....]  | 211.822            | -0.366   |
| -281 B    | Rev.' 1    | X                | 3                  | Mercury's [last appearance] in the west in Capricorn  | 287.751            | 2.914    |
| -281 B    | Rev.' 6    | X                | [15-16]            | [.... Mercury's] first appearance [in the east in Capricorn]  | 275.718            | 3.259    |
| -278 B    | 'Rev.' 9'  | XI               | 11                 | Mercury's first appearance in the west in Aquarius [....]   | 325.634            | -0.63    |
| -277 A    | Obv. 2     | I                | 4 <sup>2</sup>     | Mercury's] first appearance [in the east,] omitted  | 341.526            | -1.919   |
| -277 A    | Rev. 4     | V                | 7                  | Mercury's [first appearance] in the east [in Cancer]  | 105.342            | -1.645   |
| -277 A    | Rev. 10    | V                | 28                 | Mercury's [last appearance] in the east in Leo [....]   | 134.552            | 1.829    |
| -277 A    | Rev. 27-28 | VII              | 20                 | Mercury's first appearance in the west, omitted.  | 215.944            | -2.576   |
| -276      | 'Rev.' 1'  | X                | 26                 | Mercury's [last appearance] in Aquar[ius ....]  | 313.039            | 3.769    |
| -276      | 'Rev.' 4'  | XI               | 12                 | Mercury's first appearance in the east in Aquarius  | 302.344            | 1.47     |
| -273 B    | Obv.' 20   | VIII             | [21]               | Mercury's] first appearance [in the west] in Sagittarius... (ideal) first appearance on the 19th      | 258.619            | -1.964   |
| -270 B    | Obv.' 2    | VII              | 2                  | Mercury's first appearance in the west, omitted.  | 210.092            | -2.616   |
| -270 B    | 'Rev.' 9'  | XII <sup>2</sup> | [26-30]            | [.... Mercury's] last appearance in the east in Pisces  | 336.279            | -2.562   |
| -266 B    | 'Obv.' 16' | IX               | 1                  | Mercury's last appearance in the west in Sagittarius [....]   | 252.331            | -2.111   |
| -266 B    | 'Rev.' 6'  | XII <sub>2</sub> | Around the 10      | Mercury's [last appearance] in the west in Aries  | 11.898             | 2.897    |
| -264      | Rev.' 4-5  | VII              | 25                 | [.... Mercury's] last appearance in the west ...., omitted.   | 226.633            | -2.537   |
| -261 B    | 'Obv.' 9'  | IX               | 20                 | Mercury's first appearance in the west in Capricorn; ...(ideal) first appearance on the 19th or 18th. | 274.119            | -1.679   |
| -260      | 'Rev.' 7'  | VI               | Around the 22      | Mercury's [last appearance] in the east in the beginning of Libra                                     | 177.801            | 1.599    |
| -257 A    | 'Obv.' 7'  | II               | 4                  | Mercury's first appearance in the west in Gemini.   | 62.372             | 1.732    |
| -256      | 'Obv.' 15' | III              | [11-13]            | [.... Mercury's] last appearance in the west in Cancer.   | 93.775             | -2.753   |
| -256      | 'Rev.' 7'  | XI               | 1                  | Mercury's [last appearance] in the west [in Aquarius; ....]   | 310.603            | 3.371    |
| -256      | 'Rev.' 11' | XI               | 16 <sup>2</sup>    | Mercury's] first appearance [in the ea]st in Aquarius.  | 298.076            | 2.437    |
| -255 A    | Obv.' 12   | I                | 27                 | , Mercury's first appearance in the west in Taurus  | 40.352             | 1.802    |
| -255 B    | UE 1       | VI               | 2                  | Mercury's [first appearance] in the west [ in Virgo;] [....]  | 164.543            | -0.724   |

| Diary No. | Line       | Record           |                            |   | Tropical longitude | Latitude |
|-----------|------------|------------------|----------------------------|---|--------------------|----------|
| -255 A    | 'Rev. 14'  | VI <sub>2</sub>  | Around the 18              | Mercury's first appearance in the east in the beginning of Libra                              | 174.925            | 1.139    |
| -254      | 'Obv. 11'  | IX               | Around the 20              | Mercury's last appearance in the west in Capricorn;   | 277.041            | 2.32     |
| -254      | 'Obv. 12'  | IX               | Around the 29              | Mercury's first appearance in the east in the end of Sagittarius;                             | 266.45             | 3.617    |
| -254      | Rev.' 17   | XI               | 13                         | Mercury's last appearance in the east in Aquarius   | 303.134            | -2.05    |
| -253 A    | Obv.' 2-3  | VII              | 3                          | Mercury's [last appearance] in the ea[st in Virgo; ....                                       | 171.874            | 1.662    |
| -253 A    | 'Rev. 4'   | XII <sub>2</sub> | [9 <sup>2</sup> ]          | [... Mer]cury's last appearance in the west in the end of Aries                               | 14.366             | 2.477    |
| -251      | Obv.' 3    | VII              | 11                         | Mercury's first appearance in the west, omitted   | 217.54             | -2.439   |
| -251      | Obv.' 6    | VII              | 26                         | Mercury's last appearance in the west, omitted.   | 231.326            | -2.019   |
| -251      | Obv.' 12   | VIII             | 13                         | Mercury's first appearance in the east in Scorpius  | 216.695            | 2.583    |
| -251      | 'Rev. 12'  | XII              | 20                         | Mercury's] first appearance [in the east in Pisces].  | 329.084            | -1.353   |
| -249 B    | 'Obv.' 3'  | IX               | Around the 20              | Mercury's] first appearance in the west in Capricorn  | 289.447            | -1.399   |
| -249 B    | 'Obv.' 12' | X                | Around the 11              | [Mercury's] last appearance in the west in Aquarius   | 302.507            | 3.428    |
| -249 B    | 'Rev.' 18' | XII              | Around the 4               | Mercury's last appearance in the east in Pisces   | 326.919            | -2.346   |
| -248      | 'Obv.' 1'  | I                |                            | [... Mercury's first appearance in the west in ...., ] (ideal) first appearance on the 6th    | 29.883             | 1.421    |
| -247 C    | Obv. 8'    | X                | Around the 9               | Mercury's first appearance in the east in Sagittarius   | 259.299            | 3.541    |
| -246      | Obv.' 13   | II               | 5                          | Mercury's first appearance in the east, omitted   | 30.453             | -2.846   |
| -246      | 'Rev. 10'  | VI               | 12                         | Mercury's [last appearance] in the ea[st in Virgo ....]                                       | 162.507            | 1.831    |
| -245 B    | 'Obv. 2'   | III              | Around the 6               | Mercury's first appearance in the west in Gemini ....]  | 81.118             | 1.875    |
| -241      | Line 5'    | II               | Around the 28              | Mercury's first appearance in the east in Gemini, 1 cubit behind Jupiter, [omitted ....]      | 57.898             | -2.232   |
| -240      | Rev.' 12   | XI               | [4]                        | [... Mercury's] last appearance [in the east in Capri]corn.                                   | 292.92             | -1.911   |
| -237      | 'Obv. 7'   | III              | Around the 20              | Mercury's last appearance in the west in Cancer   | 107.713            | -2.402   |
| -237      | Rev.' 3    | IV               | [23]                       | [Mercury's first appearance in the east in Cancer.;]... (ideal) first appearance on the 21st. | 99.235             | -0.985   |
| -237      | Rev.' 9    | V                | Around the 10              | Mercury's last appearance in the east in Leo  | 124.139            | 1.715    |
| -234 A    | Obv.' 6    | VII              | 17                         | Mercury's last appearance in the east in Libra  | 186.502            | 1.313    |
| -234 A    | Obv.' 26   | IX               | 7                          | Mercury's [first appearance] in the west in Scorpius [...]                                    | 262.911            | -1.985   |
| -234 A    | Obv.' 35   | IX               | Around the 22 <sup>2</sup> | Mercury's [last appearance in the west in ....]   | 275.076            | 0.96     |
| -234 A    | 'Rev. 7'   | XI               | Around the 17              | Mercury's last appearance in the east in Aquarius   | 296.723            | -1.902   |
| -234 A    | 'Rev. 17'  | XII              | Around the 22              | Mercury's [first appearance in the west in ....]  | 0.488              | 0.613    |
| -234 A    | 'Rev. 34'  | XII <sub>2</sub> | Around the 23              | Mercury's last appearance in the west in Taurus ....]   | 28.952             | 1.695    |

| Diary No. | Line        | Record |                            |  | Tropical longitude | Latitude |
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| -232      | Obv. 14     | VIII   | 9                          | Mercury's first appearance in the east (error for west) in Sagittarius   | 243.3              | -1.261   |
| -232      | Obv. 16     | VIII   | 14                         | Mercury's last appearance in the west in Sagittarius; from its first to its last appearance, when I watched, I did not see it. | 241.339            | 0.149    |
| -232      | Obv. 21-22  | VIII   | 28                         | Mer[cury's] first appearance [in the east in Scorpius, ....] ... (ideal) first appearance on the 26th.                         | 227.113            | 3.053    |
| -232      | Rev. 3      | X      | 8                          | Mercury's [last appearance in] the east in Capricorn;  | 271.163            | -1.483   |
| -232      | Rev. 17     | XI     | Around the 14 <sup>2</sup> | Mercury's first appearance in the west in the [beginn]ing of Aquarius  | 333.723            | 0.098    |
| -230 A    | Obv.' 10-11 | I      | 24                         | Mercury's first appearance [in the west in (the beginning of) Gemini,]   | 58.529             | 1.897    |
| -230 A    | 'Rev. 10'   | VI     | Around the 12              | Mercury's first appearance in the west, om[itted]  | 198.499            | -2.354   |
| -230 A    | 'Rev. 8'    | VI     | 26                         | Mercury's [last appearance] in the west, [omitted ....]  | 211.021            | -2.858   |
| -226 A    | 'Obv. 11'   | II     | [13]                       | Mercury's] first appearance [in the east, ....] omitted.   | 26.644             | -2.833   |
| -226 A    | Rev.' 10    | III    | 19                         | Mercury's first appearance [in the west in Can]cer   | 95.21              | 1.872    |
| -225      | Obv. 10     | III    | 26                         | Mercury's last appearance in the west in Leo   | 128.988            | -3.568   |
| -225      | Rev. 12-13  | IV     | 21                         | Mercury's first appearance in the east in the beginning of Leo   | 115.675            | -1.53    |
| -222      | Rev. 4'     | X      | Around the 10              | Mercury's first appearance in the east in Capricorn  | 280.07             | 3.376    |
| -221      | Obv. 2-3    | IX     | 4                          | Mercury's [first appearance in the west] [in (the beginning of) Capricorn ....]  | 265.72             | -1.916   |
| -218      | 'Obv.' 5'   | VII    | Around the 17              | Mercury's first appearance in the west ...., omitted;  | 219.381            | -2.567   |
| -218      | 'Obv.' 5'   | VII    | 25                         | Mercury's last appearance in the west ...., [omitted ....]   | 227.512            | -2.538   |
| -218      | 'Obv.' 14'  | VIII   | 21                         | Mercury's first appearance in the east in Scorpius   | 213.79             | 2.83     |
| -214      | UE 1        | IX     | 12                         | Mercury's first appearance in the east in Sagittarius [...]  | 255.912            | 3.398    |
| -212 A    | 'Obv. 11'   | X      | 17                         | Mercury's last appearance in the east in Capricorn;  | 271.293            | -1.585   |
| -211 A    | Obv.' 8     | VI     | [25]                       | [... Mercury's] first appearance in the west, omitted.   | 210.94             | -2.487   |
| -211 B    | 'Rev.' 3'   | XI     | 4 or 5                     | Mercury's [last appearance in the west in Pisces ....]   | 329.675            | 3.421    |
| -210      | 'Obv.' 6'   | III    | 12 <sup>2</sup>            | Mercury's [last appearance in the west in Cancer ....]   | 94.477             | -3.205   |
| -209 D    | 'Obv. 19'   | III    | 4                          | [... Mercu]ry's last appearance in the west in Gemini  | 75.107             | -1.958   |
| -209 D    | Rev.' 5     | IV     | 9                          | Mercury's first appearance in the east in Gemini;...; (ideal) first appearance on the 5th                                      | 75.895             | -1.201   |
| -209 D    | Rev.' 9     | IV     | 23                         | Mercury's last appearance in the east in Cancer  | 100.725            | 1.379    |
| -209 D    | Rev.' 23    | VI     | 5                          | Mercury's first appearance in the west in Virgo; ... (ideal) first appearance on the 3rd                                       | 170.76             | -1.238   |
| -207 A    | Obv.' 16    | I      | 20 <sup>2</sup>            | Mercury's last appearance in the west in Taurus  | 33.955             | 0.342    |
| -207 A    | Obv.' 31    | II     | 19                         | Mercury's first appearance in the east ...., omitted;  | 32.75              | -3.454   |
| -207 A    | Obv.' 34    | III    | 5                          | Mercury's last appearance in the east omitted  | 53.152             | -1.001   |

| Diary No. | Line          | Record |                    |   | Tropical longitude | Latitude |
|-----------|---------------|--------|--------------------|---|--------------------|----------|
| -204 C    | Rev. 10       | I      | Around the 9       | Mercury's last appearance in the east in Aries?   | 350.663            | -2.716   |
| -203      | Obv. 4        | VIII   | 8                  | Mercury's last appearance in the east in Scorpius   | 223.687            | 0.035    |
| -202 B    | 'Obv.' 9'     | VII    | Around the 28      | Mercury's [last appearance] in the east in Libra  | 203.497            | 0.805    |
| -202 B    | 'Rev.' 4'     | XI     | Around the 20+[x]  | Mercury's] last <sup>2</sup> appearance [in the ea]st in the end of Aquarius                          | 300.25             | -1.739   |
| -201 B    | Rev. 5-6      | X      | 13                 | Mercury's first appearance in the east in Sagittarius;... (ideal) first appearance on the 8th         | 258.1              | 3.282    |
| -199 A    | 'Rev.' 6'     | V      | 15                 | Mercury's first appearance in the east in Leo   | 121.675            | -0.556   |
| -197 B    | Obv.' 6       | VII    | 19                 | Mercury's first appearance in the east in Libra, ...(ideal) first appearance on the 17th.             | 194.263            | 2.014    |
| -197 B    | Obv.' 19      | VIII   | 27                 | Mercury's [last appearance] in the east in [Sagittarius ....]   | 236.549            | -0.5     |
| -197 B    | 'Rev. 6'      | XI     | 14                 | Mercury's first appearance in the east in Aquarius  | 301.613            | 1.653    |
| -197 B    | 'Rev. 19'-20' | XII    | 13                 | Mercury's last appearance in the east in Pisces   | 327.207            | -2.391   |
| -195 D    | Obv. 1-2      | IX     | 16                 | Mercury's [last appearance] in the west [in Capricorn ....]   | 279.731            | 2.724    |
| -195 D    | Obv. 9        | IX     | Around the 24      | Mercury's first appearance in the east in Capricorn   | 270.215            | 3.635    |
| -195 E    | Obv. 9-10     | XII    | 13                 | Mercury's first appearance in the west in Aries...(ideal) first appearance on the 11th.               | 13.525             | 1.333    |
| -194 A    | 'Obv.' 4'     | II     | Around the 16      | Mercury's [first appearance] in [the east, .... omitted; ....]  | 36.63              | -3.325   |
| -194 A    | 'Obv.' 7'     | III    | 2 or 3             | [... M]ercury's last appearance in the east, .... omitted   | 57.966             | -0.673   |
| -193 A    | LE 1          | II     | 14                 | Mercury's first appearance in the east, [omitted ....]  | 23.187             | -3.001   |
| -193 A    | 'Rev. 5'      | II     | 2[8 <sup>2</sup> ] | [Mercury]ry's last appearance in the east, omitted  | 45.705             | -0.809   |
| -193 B    | 'Obv.' 28'    | VIII   |                    | [... Mercury's first appearance in the west in Sagittarius;] ... (ideal) first appearance on the 20th | 245.583            | -2.198   |
| -193 B    | 'Obv.' 28'    | VIII   | Around the 29      | Mercury's last appearance in the west in Sagittarius  | 251.016            | -0.738   |
| -193 D    | 'Obv.' 15'    | X      | [28 or 29]         | [... Mercury's] last appearance [in the east in Cap]ricorn;   | 279.206            | -1.659   |
| -193 D    | 'Rev. 17'     | XII    | [2 or 3]           | Mercury's [first appearance] in the west in Pisces[...]   | 339.141            | 0.093    |
| -192 A    | Obv. 2-4      | II     | 18                 | Mercury's first [appearance] in the west in Gemini;... (ideal) first appearance on the 16th.          | 81.298             | 1.949    |
| -191 A    | Line 3'       | IV     | Around the 22      | Mercury's [first appearance] in the [east in Cancer ....]   | 99.294             | -1.295   |
| -191 B    | Obv. 6        | VIII   | [5-8]              | Mercury's first appearance in the east in the end of Libra  | 203.396            | 2.381    |
| -190 B    | 'Obv.' 3'     | II     | Around the 6       | Mercury's first appearance in the west in the end of Taurus   | 45.648             | 1.546    |
| -190 B    | 'Obv.' 19'    | III    | 16                 | Mercury's last appearance in the west in the beginning of Cancer                                      | 89.886             | -2.441   |
| -190 B    | 'Rev.' 5'     | IV     | Around the 17      | [Mercury's first appearance in the east in Gemini ....]   | 82.863             | -1.931   |

| Diary No. | Line         | Record           |                            |   | Tropical longitude | Latitude |
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| -190 E    | Line 5'      | XII              | 27                         | Mercury's last appearance in the east in Pisces [...]   | 327.182            | -2.371   |
| -189 A    | 'Obv.' 11'   | II               | Around the 8               | Mercury's last appearance in the west in Gemini   | 70.266             | -1.063   |
| -189 B    | 'Obv.' 6'    | VI               |                            | [... Mercury's first appearance in the east in Virgo; ....] (ideal) first appearance on the 24th;                   | 171.859            | 0.976    |
| -188      | Obv. 4-5     | I                | 1                          | Mercury's first appearance in the west in the beginning of Taurus;...   | 25.039             | 1.733    |
| -187 A    | Obv.' 16     | VIII             | 3                          | Mercury's first appearance in the west in Sagittarius,  | 251.106            | -2.183   |
| -187 A    | 'Rev.' 2'    | XI               | Around the 15              | Mercury's [first appearance in] the west in [Pisces; ....]  | 344.934            | 0.046    |
| -186 C    | Obv. 15-16   | XI               | 14                         | Mercury's first appearance in the west in [Virgo]...(ideal) first appearance on the 12th.                           | 336.188            | 0.279    |
| -186 A    | 'Rev.' 5'    | XII              | 1                          | Mercury's [last appearance] in the west in Pisces alt: the end of Pisces  | 353.137            | 3.408    |
| -183 C    | Rev.' 1      | IV               | [1 or 2]                   | Mercury's first appearance in the east in Gemini ....] (ideal) first appearance on the 26th of month III .... [...] | 80.42              | -1.149   |
| -182 A    | 'Obv.' 13'   | II               | 23                         | Mercury's last appearance in the west in Gemini   | 59.777             | -2.191   |
| -182 A    | 'Rev.' 12'   | VIII             | 4 <sup>2</sup>             | Mercury's [last appearance] in the east [in Libra   | 197.265            | 1.062    |
| -182 A    | 'Rev.' 38'   | X                | 17                         | Mercury's first appearance in the east in Capricorn   | 277.018            | 3.605    |
| -180 D    | Rev. 9-10    | XI               | 8                          | Mercury's [first appearance in the west in Pisces]  | 303.582            | -2.034   |
| -178 A    | Obv.' 9      | V                | [10 or 11]                 | [... Mercury's] last appearance [in the east] in Leo  | 135.297            | 1.817    |
| -178 B    | UE 1'        | VII              | Around the 2               | Mercury's first appearance in the west, .... omitted.   | 213.731            | -2.687   |
| -178 C    | Obv.' 9      | XI               | [11]                       | Mercury's last appearance in the west in P[isces <sup>2</sup> ];  | 325.106            | 3.795    |
| -178 C    | 'Rev.' 13'   | XII              | 29                         | Mercury's last appearance in the east in the end of Pisces  | 345.391            | -2.531   |
| -175 B    | Obv.' 3      | IX               | 1                          | Mercury's first appearance in the west in the end of Sagittarius  | 263.504            | -2.054   |
| -173 A    | Obv.' 16     | VIII             | 1                          | Mercury's first appearance in the west in Sagittarius   | 245.382            | -1.866   |
| -173 A    | 'Rev.' 5'    | XII              | 3                          | Mercury's last appearance in the west in Aries  | 355.272            | 3.447    |
| -171 B    | Obv.' 3      | V                | 18                         | Mercury's last appearance in the east in the beginning of Leo   | 123.358            | 1.724    |
| -171 A    | 'Rev.' 6'    | XII <sub>2</sub> | 16                         | Mercury's last appearance in the east in Aries  | 349.3              | -2.213   |
| -170 C    | 'Rev.' 3'-5' | III              | 24                         | Mercury's first appearance in the east in Gemini ... (ideal) first appearance on the 22nd;                          | 78.904             | -1.997   |
| -170 E    | Obv. 7-10    | VII              | 7                          | Mercury's first appearance [in the east] in Libra   | 183.478            | 1.619    |
| -168 A    | Obv.' 12     | V                | 27                         | Mercury's first appearance in the west <sup>sic</sup> in Virgo; ... (ideal) first appearance on the 25th            | 151.677            | 0.279    |
| -168 A    | Obv.' 25     | VI               | [23                        | Mercury's] last appearance in the east in (the beginning of) Libra  | 184.07             | 1.354    |
| -168 A    | Rev. 10'-11' | VIII             | Around the 15 <sup>2</sup> | Mercury's first appearance in the west in Sagittarius;  | 262.936            | -1.9     |

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| -168 E    | Obv.' 2-3      | IX     | Around the 2    | Mercury's [last appearance] in the west [in Capricorn.   | 270.166            | 1.764    |
| -165 A    | 'Rev.' 5'      | V      | Around the 1    | Mercury's last appearance in the east in Leo   | 128.784            | 1.743    |
| -164 B    | 'Obv.' 9       | VII    | 22              | Mercury's first appearance in the east in Libra;... (ideal) first appearance on the 20th;                          | 192.932            | 1.852    |
| -164 B    | 'Rev.' 17'     | XII    | 6 <sup>2</sup>  | Mercury's last appearance in the east <sup>2</sup> in ....;  | 311.896            | -1.548   |
| -163 B    | Obv.' 15       | VIII   | Around the 18   | Me[rcury's last appearance in the east in Scorpius ....]   | 211.431            | 0.588    |
| -163 C    | Rev.' 4        | XI     | 10              | [first appearance] in the east in Capricorn  | 282.544            | 2.616    |
| -163 C    | 'Rev.' 3'      | XII    | Around the 14   | Mercury's [last appearance in the east in Aquarius ....] [the end of]  | 316.127            | -2.213   |
| -162      | Obv. 14-15     | V      | 16              | Mercury's last appearance in the west [in Virgo] <sup>2</sup> : from the 14th on, when I watched I did not see it. | 174.407            | -3.211   |
| -161 A    | 'Obv.' 11'     | I      | Around the 18   | Mercury's last appearance in the west in Taurus ....]  | 35.616             | 0.635    |
| -161 B    | 'Obv.' 21'-22' | II     | Around the 19   | Mercury's [first appearance] in the east, [omitted ....]   | 34.543             | -3.374   |
| -161 B    | 'Rev.' 7'      | V      | Around the 15   | Mercury's last appearance in the west in Virgo   | 159.852            | -3.715   |
| -161 A    | 'Rev.' 10'     | VI     | Around the 7    | Mercury's first appearance in the east in the end of Leo; .... [...]   | 145.058            | -0.351   |
| -160 C    | 'Obv.' 2'      | XI     | Around the 4    | Mercury's first appearance in the west in Pisces   | 336.767            | -0.06    |
| -158 B    | 'Rev.' 5'      | V      | [Around the 15] | Mercury's last appearance in the east in Leo   | 128.213            | 1.787    |
| -158 C    | Line 10'       | VII    | 5               | Mercury's first appearance in the west ...., omitted;  | 205.744            | -2.479   |
| -157 A    | Obv. 5-6       | IV     | 5               | [Mercury's] last appearance [in the east] in Cancer  | 104.809            | 1.253    |
| -156 A    | 'Obv.' 17'     | I      | Around the 2    | Mercury's first appearance in the west in Taurus   | 24.962             | 0.898    |
| -155 A    | Obv. 14        | IV     | 24              | Mercury's [first appearance] in the west in Leo  | 128.964            | 1.131    |
| -154 B    | LE 2-4         | XI     | 21              | Mercury's first appearance in the west in the end <of Aquarius>;... (ideal) first appearance on the 18th ....      | 348.251            | 0.487    |
| -153      | 'Rev.' 3'      | V      | [Around] the 10 | Mercury's first appearance in the east in Leo;   | 122.326            | -2.137   |
| -149 A    | Obv.' 3'       | III    | 10              | Mercury's [last appearance] in the east in Gemini [...]  | 82.407             | 0.62     |
| -149 B    | 'Rev. 5'-6'    | VII    | Around the 7    | Mercury's last appearance in the east in Libra;  | 196.86             | 1.033    |
| -148      | Line 8'        | IX     | 22              | Mercury's first appearance in the east in Sagittarius  | 252.255            | 3.281    |
| -146      | 'Obv. 2'       | IX     | Around the 19   | Mercury's [last appearance] in the east [in Sagittarius ....]  | 261.017            | -1.114   |
| -146      | Rev.' 5        | X      | 25              | Mercury's first appearance in the west in the beginning of Pisces .... [...]                                       | 323.7              | -0.488   |
| -144      | 'Obv. 33'      | VII    | Around the 27   | Mercury's [first appearance] in the east in Libra  | 189.873            | 1.257    |
| -144      | Rev.' 23       | IX     | Around the 1    | Mercury's last appearance in the east in Scorpius  | 222.392            | 0.316    |
| -143 A    | Line 23'       | V      | 3               | Mercury's first appearance in the west in Virgo  | 157.041            | -0.132   |
| -143 A    | Line 30'       | V      | 18              | Mercury's last appearance in the west in Virgo   | 176.937            | -2.116   |



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| -143 B    | Rev.' 5     | VI              | Around the 24   | Mercury's first appearance in the east in Virgo  | 172.967            | 0.947    |
| -141 A    | 'Obv.' 7'   | I               | Around the 23   | Mercury's last appearance in the west in Taurus  | 30.337             | 1.022    |
| -141 A    | 'Obv.' 16'  | II              | Around the 28   | Mercury's first appearance in the east .... omitted [...]  | 32.604             | -3.106   |
| -141 D    | 'Obv.' 13'  | VI <sub>2</sub> | Around the 8    | , Mercury's [last appearance] in the west <sup>sic</sup> in Virgo [east]                                     | 168.34             | 1.761    |
| -141 F    | 'Obv.' 31'  | VIII            | Around the 17   | Mercury's last appearance in the west in Sagittarius   | 260.908            | 0.337    |
| -141 F    | 'Rev. 24'   | XII             | Around the 11   | Mercury's last appearance in the west in Aries   | 12.336             | 3.011    |
| -140 A    | Obv.' 15    | I               | Around the 25   | Mercury's [first appearance in the east ...., omitted ....]  | 7.663              | -3.285   |
| -140 C    | 'Rev. 27'   | X               | Around the 8    | Mercury's last appearance in the east in Capricorn   | 274.111            | -1.55    |
| -140 D    | Rev.' 7-8   | XI              | 14              | Me[r]cury's first appearance in the west in Pisces;... (ideal) first appearance on the 10th                  | 338.606            | 0.464    |
| -137 A    | 'Obv.' 11'  | II              | Around the 24   | Mercury's last appearance in the west in Gemini  | 82.911             | -1.697   |
| -137 C    | 'Rev. 2'    | VIII            | Around the 12   | Mercury's [last appearance in the east in Scorpius ....]   | 218.25             | 0.323    |
| -137 D    | 'Obv. 5'    | IX              | [27]            | Mercury's] first appearance in the west in Capricorn; .. (ideal) first appearance on the 25th                | 290.532            | -1.237   |
| -137 D    | Rev.' 12-13 | X               | [Around the 17] | [Mer]cury's last appearance in the west in Aquarius  | 300.241            | 3.336    |
| -137 D    | Rev.' 29    | XI              | Around the 2    | Mercury's first appearance in the east in the end of Capricorn;  | 288.171            | 2.633    |
| -136 A    | 'Obv. 8'    | VII             | 6               | Mercury's first appearance in the east in Virgo;   | 166.014            | 1.132    |
| -136 C    | 'Obv.' 7'   | X               | 10              | last appearance of Mercury in the west in Capricorn: [from] the 7th, when I watched I did not see it.        | 286.624            | 1.383    |
| -136 C    | 'Obv.' 13'  | X               |                 | [... Mercury's ....] (ideal) first appearance on the 21st  | 274.002            | 3.647    |
| -134 B    | 'Rev. 4'    | XI              | 26              | Mercury's first appearance in the west in Pisces [...]   | 339.024            | -0.187   |
| -133 A    | 'Obv. 6'    | VI              | [10 to 13]      | Mercury's] last appearance in the east in Leo.   | 141.949            | 1.86     |
| -133 B    | 'Obv. 12'   | XI              | 21              | Mercury's first appearance in the west in the beginning of Pisces;..., (ideal) first appearance on the 20th. | 326.704            | -0.363   |
| -133 B    | Rev.' 15    | XII             | Around the 16   | Mercury's last appearance in the west in the end of Pisces;  | 345.038            | 3.597    |
| -132 A    | 'Obv.' 13'  | II              |                 | Mercury's first appearance in the west in Gemini;... [(ideal) first appearance] on the 5th [...]             | 63.255             | 1.734    |
| -132 B    | Obv. 31     | VII             | 2               | Mercury's first appearance in the west ...., omitted   | 215.613            | -2.716   |
| -132 B    | Rev. 17     | VII             | 14 or 5         | Mer[cury's last appearance in the west ....], omitted  | 222.862            | -2.104   |
| -132 B    | Rev. 17     | VII             | Around the 29   | Mercury's [first appearance in] the east in Scor[pius  | 208.03             | 2.19     |
| -132 D    | 'Obv.' 17'  | IX              | Around the 13   | Mercury's last appearance in the east in Sagittarius   | 254.354            | -1.156   |
| -132 D    | 'Rev' 12'   | X               | Around the 14   | Mercury's first appearance in the west in Aquarius   | 307.184            | -1.191   |

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|-----------|------------|-----------------|----------------------------|--|--------------------|----------|
| -132 D    | 'Rev.' 26' | XII             | 29                         | last appearance of Mercury in the east in Pisces: from the 25th, when I watched I did not see it   | 347.722            | -2.506   |
| -131 B    | Obv. 2-4   | XI              | 22                         | Mercury's first appearance in the east in Aquarius;...; (ideal) first appearance on the 19th       | 298.232            | 1.496    |
| -130 D    | Rev.' 17   | XII             | 23                         | Mercury's [...] in the west in Aries   | 23.065             | 1.336    |
| -129 A    | 'Obv.' 4'  | I               | Around the 26              | Mercury's last appearance in the west in the end of Taurus   | 54.48              | 0.052    |
| -129 A    | 'Rev.' 7'  | IV              | 14                         | Mercury's first appearance in the west in Leo ....   | 131.137            | 1.176    |
| -129      | 'Rev.' 8'  | V               | Around the 22              | Mercury's last appearance in the west in Virgo   | 174.462            | -3.55    |
| -126 A    | 'Obv.' 4'  | VIII            | Around the 13              | Mercury's first appearance in the east in Scorpius   | 218.874            | 2.225    |
| -125 A    | Obv.' 12   | I               | Around the 12              | [Mercury's last appearance in the west in Pisces   | 351.726            | -2.676   |
| -125 A    | Obv.' 6    | I               | 16                         | last appearance of Mercury in the east in Aries: from the 12th on, when I watched I did not see it | 358.621            | -2.447   |
| -125 A    | 'Rev.' 4'  | V               | Around the 17              | Mercury's [last appearance in] the east [in Leo  | 123.998            | 1.72     |
| -124 A    | 'Obv.' 22' | II              | 22                         | Mercury's last appearance in the west in the beginning of Cancer                                   | 85.804             | -2.37    |
| -124 A    | 'Obv.' 33' | III             | Around the 22              | Mercury's [first appearance in the east in Gemini ....]  | 78.934             | -2.282   |
| -124 A    | 'Rev.' 25' | VI              | 1                          | Mercury's [first appearance] in the west in Libra  | 188.167            | -2.266   |
| -124 A    | 'Rev.' 17' | VI              | 10                         | Mercury's last appearance in the [west in Libra; ....]   | 197.083            | -3.049   |
| -124 B    | 'Obv.' 18' | IX              | Around the 21              | Mercury's first appearance in the west in Capricorn  | 288.641            | -1.526   |
| -124 B    | 'Rev.' 11' | X               | 2                          | Mercury's last appearance in the west in Aquarius  | 302.535            | 0.316    |
| -124 B    | 'Rev.' 7'  | X               | Around the 28 <sup>2</sup> | Mercury's first appearance in the east in the end of Capricorn                                     | 290.93             | 2.535    |
| -124 B    | 'Rev.' 21' | XI              | 2                          | Mercury's first appearance in the east in the end of Capricorn                                     | 291.029            | 1.662    |
| -123 A    | 'Obv.' 11' | III             | 19                         | Mercury's first appearance in the east in Gemini;... (ideal) first appearance on the 16th [...]    | 65.351             | -2.063   |
| -123 C    | Line 11'   | V               | Around the 10              | Mercury's [first appearance in the west in Virgo ....]   | 153.911            | -0.078   |
| -122 A    | 'Obv.' 10' | II              | Around the 4               | Mercury's last appearance in the west in Taurus  | 46.136             | 0.859    |
| -122 C    | 'Obv.' 10' | III             | [24]                       | [... Mercury's] first appearance in [... to the ea]st;... (ideal) first appearance on the 23rd     | 66.543             | -0.236   |
| -122 C    | 'Obv.' 11' | III             | [25]                       | [... Mercury's] last appearance [in the east] in Gemini;   | 68.472             | -0.039   |
| -122 D    | 'Rev.' 9'  | VI <sub>2</sub> | Around the 21              | Mercury's last appearance in the east in Libra   | 181.461            | 1.543    |
| -121      | 'Obv.' 4'  | III             | Around the 17              | Mercury's [first appearance] in the west in Cancer [...]   | 104.993            | 1.767    |
| -120      | 'Obv.' 4'  | IV              | Around the 19              | Mercury's last appearance in the west in Leo   | 133.682            | -3.211   |
| -119 C    | 'Obv.' 10' | II              | Around the 3               | Mercury's first appearance in the west in Gemini [...]   | 68.289             | 1.85     |

| Diary No. | Line              | Record |                   |   | Tropical longitude | Latitude |
|-----------|-------------------|--------|-------------------|---|--------------------|----------|
| -119 C    | 'Obv. 19'         | III    | 20                | Mercury's last appearance in the west,  | 114.858            | -4.167   |
| -118 A    | Obv.' 15          | I      | 30                | Mercury's first appearance in the west [in the beginn]ing of Gemini, ... (ideal) first appearance [on the 27th in the end of Taur]us. | 56.372             | 1.86     |
| -118 A    | 'Rev. 17'         | VII    | Around the 1      | Mercury's [last appearance] in the west, .... [omitted?]  | 209.035            | -2.953   |
| -118 A    | 'Rev. 9'          | VII    | 21                | Mercury's [first appearance] in the east in Libra   | 194.063            | 1.833    |
| -117 B    | 'Rev.' 13'        | XII    | [14]              | [... Mercu]ry's last appearance in the east in the end of Aquarius.   | 318.412            | -2.244   |
| -112      | Obv.' 3           | VII    | 1 to 8            | [... Mercury's ....] first appearance in the west ...., omitted   | 205.293            | -2.39    |
| -111 A    | Obv.' 6           | I      | 10                | Mercury's first appearance [in the west in] Taurus;... [ (ideal) first appearance on the 8th ....]                                    | 49.902             | 1.791    |
| -111 B    | 'Obv.' 4'         | II     | Around the 15     | Mercury's [last appearance] in the west in the beginning of Ca[ncer ....]   | 89.071             | -1.471   |
| -110      | 'Rev.' 12'        | V      | Around the 4      | Mercury's first appearance in the west in Virgo   | 153.586            | 0.091    |
| -110      | 'Rev.' 12'        | V      | Around the 27     | Mercury's [last appearance in the west in the end of Virgo ....]  | 182.131            | -2.88    |
| -109 A    | 'Obv.' 18'        | IX     | [9 to 13]         | [... Mercury's] first appearance [in the west ....], ... (ideal) first appearance on the 7th in Sagittarius                           | 263.738            | -1.995   |
| -108 A    | 'Obv.' 18'        | II     | Around the 5      | Mercury's first appearance in the east ...., omitted.   | 35.436             | -2.639   |
| -108 A    | 'Obv.' 36'        | III    | 12                | Mercury's [first appearance in the west in Cancer ....]   | 104.19             | 1.804    |
| -108 A    | 'Rev.' 12'        | IV     | Around the 21     | Mercury's last appearance in the west in the beginning of Virgo   | 153.235            | -3.349   |
| -108 A    | 'Rev.' 16'        | V      |                   | [... Mercury's] first appearance [in the east in] Leo; ... (ideal) first appearance on the 15th.                                      | 139.606            | -1.044   |
| -107 A    | Obv.' 6           | IV     | Around the 18     | Mercury's last appearance in the west in Leo  | 136.777            | -3.623   |
| -105 A    | 'Obv.' 8'         | I      | [Around the 24]   | Mercury's first] appearance [in the west in Gemini  | 57.424             | 1.819    |
| -105      | 'Obv.' A35', B32' | III    | Around the 5 or 6 | Mercury's last appearance in the west in Cancer   | 100.263            | -2.785   |
| -105 A    | 'Obv.' 48'        | IV     | 5                 | Mercury's first appearance in the east in Cancer,   | 92.282             | -1.51    |
| -105 A    | 'Rev. 27'         | VI     | [Around the 3]    | Mercury's first appearance in the west ...., omitted.]  | 184.794            | -1.188   |
| -105 A    | 'Rev. 35'         | VI     | Around the 2[6]   | [Mercury's] last appearance in the west ....,   | 210.734            | -2.949   |
| -105 A    | 'Rev. 45'         | VII    | Around the 17     | Mercury's first appearance in the east in Libra   | 197.041            | 1.783    |
| -103 A    | Line 12'          | II     | Around the 17     | Mercury's last appearance in the west in Gemini   | 61.005             | -0.038   |
| -103 B    | 'Obv.' 1'         | VIII   | [1]7              | Mercury's [first appearance] in the west in [Sagittarius ....]  | 260.421            | -2.155   |
| -99 A     | Line 11'          | VIII   | 2                 | Mercury's first appearance in the east in the end of Libra  | 206.833            | 2.021    |
| -99 B     | Line 6'           | IX     | 10                | Mercury's last appearance in the east in Sagittarius  | 244.639            | -0.577   |

| Diary No. | Line          | Record           |               |  | Tropical longitude | Latitude |
|-----------|---------------|------------------|---------------|--|--------------------|----------|
| -98 C     | Obv. 14-15    | X                | 12            | Mercury's first appearance in the west in Capricorn  | 291.083            | -1.576   |
| -98 C     | Obv. 17       | X                | Around the 27 | Mercury's last appearance in the west in Aquarius  | 310.309            | 1.466    |
| -97 C     | Rev. 11       | II               | Around the 6  | Mercury's last appearance in the west in Gemini  | 72.564             | -1.011   |
| -97       | Rev.' 4       | V                | 3             | Mercury's first appearance in the west in Virgo  | 159.228            | -0.249   |
| -96 A     | Line 14'      | II               | Around the 1  | Mercury's [last appearance] in the west in the end of Taurus [....]  | 51.638             | -0.565   |
| -95 D     | Line 6'       | II               | 28            | Mercury's [first appearance] in the east [...., omitted ....]  | 33.436             | -3.13    |
| -95 E     | Line 10'      | V                | 20            | Mercury's last appearance in the west in Virgo: from the 18th, when I watched I did not see it                                       | 156.636            | -3.764   |
| -95 C     | 'Rev.' 3'     | VI               | 16            | Mercury's first appearance in the east in the end of Leo   | 142.337            | 0.352    |
| -94       | Line 9'       | II               | Around the 9  | Mercury's last appearance in the east ...., omitted  | 44.433             | -0.675   |
| -93 A     | Rev.' 22      | V                | Around the 4  | Mercury's first appearance in the east in the end of Cancer  | 109.632            | -1.506   |
| -93 A     | Rev.' 19      | V                | Around the 22 | Mercury's last appearance in the east in Leo   | 133.444            | 1.772    |
| -90       | 'Obv. 48'     | X                | Around the 7  | Mercury's last appearance in the west in Capricorn   | 287.46             | 1.652    |
| -90       | 'Obv. 48'     | X                | Around the 22 | Mercury's first appearance in the east in Capricorn  | 273.102            | 3.374    |
| -90       | Rev.' 19      | XII              | Around the 2  | Mercury's last appearance in the east in Aquarius  | 309.096            | -2.102   |
| -87 A     | 'Rev.' 13'    | VI               | Around the 11 | Mercury's last appearance in the east in the end of Leo  | 146.216            | 1.866    |
| -87 C     | 'Rev. 40'-41' | XII <sub>2</sub> | [16 or 17]    | .... Mercury's] first appearance in the east in the end of Pisces;... (ideal) first appearance on the 15th in Pisces.                | 341.418            | -2.314   |
| -87 C     | 'Rev. 45'     | XII <sub>2</sub> | 27            | Mercury's last appearance in the east in Aries   | 353.698            | -2.845   |
| -86 A     | 'Rev.' 6'     | V                | Around the 4  | Mercury's last appearance in the east in Leo   | 129.017            | 1.742    |
| -86 B     | Line 12'      | VIII             | 1             | Mercury's first appearance in the east in the beginning of Scorpius; ..., [(ideal) first appearance] on the 28th [of month VII ....] | 208.081            | 2.474    |
| -85 B     | Line 8'       | VII              | Around the 7  | Mercury's last appearance in the west ...., omitted.   | 208.039            | -2.846   |
| -85 C     | Rev.' 3       | X                | [10]          | Mercury's first appearance in the west in Aquarius;]..., (ideal) first appearance on the 9th in the beginning of Aquarius            | 295.671            | -1.376   |
| -85 C     | Rev.' 16      | XI               | 4             | Mercury's last appearance in the west in Aquarius: from the 1st, when I watched I did not see it                                     | 310.524            | 3.651    |
| -85 C     | Rev.' 23-24   | XI               | Around the 19 | Mercury's [first appearance] in the east [in Aquarius ....]  | 299.183            | 1.982    |
| -85 C     | 'Rev.' 12'    | XII              | Around the 22 | Mercury's last appearance in the east in Pisces  | 331.397            | -2.412   |
| -83       | 'Obv.' 10'    | III              | 6             | Mercury's first appearance in the east in Gemini   | 60.391             | -1.738   |
| -82 B     | 'Rev.' 11'    | XII <sub>2</sub> | Around the 10 | Mercury's last appearance in the west in Aries ....]   | 15.699             | 2.486    |

| Diary No. | Line       | Record |                           |  | Tropical longitude | Latitude |
|-----------|------------|--------|---------------------------|--|--------------------|----------|
| -78       | Line 2'    | VI     | 1 to 10                   | [... Mercury's] last appearance [in the west ....], omitted  | 191.232            | -2.463   |
| -77 A     | 'Obv. 5'   | I      | Around the 5 <sup>2</sup> | Mercury's first appearance in the west in Taurus   | 27.296             | 1.085    |
| -77 A     | 'Obv. 18'  | II     | Around the 13             | Mercury's last appearance in the west in Gemini;   | 67.227             | -0.92    |
| -77 A     | 'Obv. 37'  | III    | 18                        | , Mercury's first appearance in the east in Gemini, ... (ideal) first appearance on the 16th         | 66.179             | -2.095   |
| -77 A     | Rev.' 6    | IV     | Around the 2              | Mercury's last appearance in the east in the end of Gemini   | 87.135             | 0.663    |
| -77 A     | Rev.' 22   | V      | 13                        | Mercury's first appearance in the west in Virgo; ... (ideal) first appearance on the 12th .... [...] | 160.399            | -0.596   |
| -77 A     | Rev.' 28   | V      | Around the 29             | Mercury's last appearance in the west in the end of Virgo;   | 179.449            | -2.72    |
| -77 A     | Rev.' 32   | VI     | 2                         | last appearance of Mercury in the west in the end of Virgo...  | 181.937            | -3.044   |
| -77 B     | 'Obv.' 10' | VII    | Around the 30             | Mercury's last appearance in the east in Libra   | 204.448            | 0.797    |
| -77 B     | 'Rev.' 12' | XI     | Around the 28             | Mercury's last appearance in the east in Aquarius  | 311.867            | -2.146   |
| -73       | Line 10'   | III    | Around the 16             | Mercury's last appearance in the west in the beginning of Leo  | 116.966            | -3.606   |
| -60       | 'Obv. 5'   | VIII   | 7                         | Mercury's [last appearance] in the west in Scor[p]ius ....]  | 228.796            | -1.615   |
| -60       | Rev.' 4    | VIII   | Around the 23             | Mercury's first appearance in the east in Scorpius   | 213.048            | 2.669    |

## Appendix K2: Mercury phenomena from the planetary texts (ADART Vol. V)

| ADART Vol. V |                  |                 |                    |          |        |                   |        |    |                     | Tropical                 | Latitude |        |
|--------------|------------------|-----------------|--------------------|----------|--------|-------------------|--------|----|---------------------|--------------------------|----------|--------|
| No.          | Observation date |                 |                    |          |        |                   |        |    |                     | Longitude                |          |        |
| 59           | Obv. III 3'      | A II year 15    | V                  | 24       | [last] | appearance in the | east   | in | end [of Leo]        | 138.385                  | 1.842    |        |
| 59           | Obv. III 4'      | Arta II year 15 | [VII]              | 25       | last   | appearance in the | west   |    | omitted             | 226.643                  | -2.451   |        |
| 59           | Obv. III 5'      | Arta II year 15 | [VIII]             | [...]    | first  | appearance in the | [east] |    | [...]               | (ideal) first on 12      | 215.799  | 2.086  |
| 59           | Obv. III 7'      | Arta II year 15 | [IX <sup>2</sup> ] | 30       | last   | appearance in the | east   | in | Sagittarius         |                          | 259.694  | -1.345 |
| 59           | Obv. III 8'      | Arta II year 16 | XI                 |          | first  | appearance in the | west   | in | Aquarius            | (ideal) first on 28 of X | 308.164  | -1.276 |
| 59           | Obv. III 9'      | Arta II year 16 | XI                 | 25       | last   | appearance in the | west   | in | Pisces              |                          | 334.433  | 3.703  |
| 59           | Obv. III 9'-10'  | Arta II year 16 | XII                | 28       | first  | appearance in the | east   | in | Pisces              |                          | 330.311  | -2.086 |
| 59           | Obv. III 11'     | Arta II year 16 | I                  | 13 or 14 | last   | appearance in the | east   | in | end of Pisces       |                          | 349.263  | -2.638 |
| 59           | Obv. III 12'-13' | Arta II year 16 | II                 | 18       | first  | appearance in the | west   | in | beginning of Gemini | (ideal) first on 14      | 56.091   | 1.786  |

| <i>ADART</i> Vol. V<br>No. |                     | Observation<br>date |                  |               |         |                   |        |    |                     |                       | Tropical<br>Longitude | Latitude |
|----------------------------|---------------------|---------------------|------------------|---------------|---------|-------------------|--------|----|---------------------|-----------------------|-----------------------|----------|
| 59                         | Obv. III 14'        | Arta II year 16     | IV               | 1             | last    | appearance in the | west   | in | Cancer              |                       | 101.335               | -3.303   |
| 59                         | Obv. III<br>14'-15' | Arta II year 16     | IV               | 27            | first   | appearance in the | east   | in | beginning of Cancer | (ideal) first on 25   | 91.49                 | -1.866   |
| 59                         | Obv. III<br>15'-16' | Arta II year 16     | V                | 16            | last    | appearance in the | [east] | in | beginning of Leo    |                       | 119.26                | 1.687    |
| 59                         | Obv. III 16'        | Arta II year 16     | VI <sub>2</sub>  | 5             | first   | appearance in the | west   |    | omitted             |                       | 197.019               | -2.199   |
| 59                         | Obv. III<br>16'-17' | Arta II year 16     | VI <sub>2</sub>  | 15            | last    | appearance in the | west   |    | omitted             |                       | 208.139               | -2.851   |
| 59                         | Obv. III<br>17'-18' | Arta II year 16     | VII              | 13            | first   | appearance in the | east   | in | Libra               | (ideal) first on 8    | 196.523               | 2.306    |
| 59                         | Obv. IV 10'         | Arta II year 19     | [X]              | [2]5          | last    | appearance in the | east   | in | Capricorn           |                       | 293.537               | -1.907   |
| 59                         | Obv. IV 11'         | Arta II year 19     | XI               | [...]         | first   | appearance in the | [west] |    | [...]               | (ideal) first on 24   | 347.443               | -0.196   |
| 59                         | Obv. IV 13'         | Arta II year 20     | II <sup>p</sup>  | 25            | last    | appearance in the | east   |    | omitted             |                       | 55.695                | 0.055    |
| 59                         | Obv. IV<br>13'-14'  | Arta II year 20     | III              | Around the 13 | [first] | appearance in the | [west] |    | [...]               |                       | 92.729                | 1.865    |
| 59                         | Obv. IV 14'         | Arta II year 20     | [IV]             | [2]9          | last    | appearance in the | west   | in | Leo                 |                       | 147.562               | -3.874   |
| 59                         | Obv. IV<br>14'-15'  | Arta II year 20     | V                | 22            | [first] | appearance in the | east   | in | end [of Leo]        | (ideal) first [on 1]9 | 133.011               | -0.489   |
| 59                         | Obv. IV<br>16'-17'  | Arta II year 20     | VIII             | 10            | first   | appearance in the | west   | in | Sagittarius         |                       | 245.266               | -2.233   |
| 59                         | Obv. IV 17'         | Arta II year 20     | VIII             | 22            | last    | appearance in the | west   | in | Sagittarius         |                       | 253.466               | -0.289   |
| 59                         | Obv. IV<br>17'-18'  | Arta II year 20     | IX               | 10            | first   | appearance in the | east   | in | Sagittarius         | (ideal) first on 8    | 237.392               | 3.165    |
| 59                         | Obv. IV 19'         | Arta II year 20     | X                | 19            | last    | appearance in the | east   | in | Capricorn           |                       | 279.099               | -1.64    |
| 59                         | Obv. IV<br>19'-20'  | Arta II year 20     | XI               | 21            | first   | appearance in the | west   | in | Pisces              | (ideal) first on 20   | 335.388               | -0.362   |
| 59                         | Obv. IV<br>22'-23'  | Arta II year 20     | XII <sub>2</sub> | 26            | first   | appearance in the | east   |    | omitted             |                       | 3.115                 | -3.181   |
| 59                         | Obv. IV 24'         | Arta II year 21     | I                | Around the 12 | [last]  | appearance in the | [east] |    | omitted             |                       | 26.118                | -1.704   |
| 59                         | Obv. IV<br>24'-25'  | Arta II year 21     | II               | 8             | first   | appearance in the | west   | in | Gemini              |                       | 77.234                | 1.856    |
| 59                         | Obv. IV 26'         | Arta II year 21     | III              | 22            | last    | appearance in the | west   | in | Leo                 |                       | 130.32                | -3.606   |
| 59                         | Obv. IV 27'         | Arta II year 21     | I[V]             | [1]5          | first   | appearance in the | east   | in | Leo                 | (ideal) first on 13   | 116.779               | -1.927   |

| ADART Vol. V<br>No. | Observation<br>date |                 |      |               |         |                   |      |    |                    | Tropical<br>Longitude         | Latitude       |
|---------------------|---------------------|-----------------|------|---------------|---------|-------------------|------|----|--------------------|-------------------------------|----------------|
| 59                  | Obv. IV<br>28'-29'  | Arta II year 21 | VII  | 3             | first   | appearance in the | west | in | Scorpius           |                               | 227.741 -2.513 |
| 59                  | Obv. IV<br>29'-30'  | Arta II year 21 | VIII | 3             | first   | appearance in the | east | in | Scorpius           | (ideal) first on 29 of<br>VII | 221.859 2.968  |
| 59                  | Obv. IV<br>31'-32'  | Arta II year 21 | IX   | Around the 12 | last    | appearance in the | east | in | Sagittarius        |                               | 261.764 -1.175 |
| 59                  | Obv. IV 32'         | Arta II year 21 | X    | 15            | first   | appearance in the | west | in | Aquarius           | (ideal) first on 13 or<br>14  | 319.421 -0.867 |
| 59                  | Obv. IV 33'         | Arta II year 21 | XI   | Around the 10 | last    | appearance in the | west | in | Pisces             |                               | 345.498 3.586  |
| 59                  | Obv. IV<br>33'-34'  | Arta II year 21 | XII  | 18            | [first] | appearance in the | east |    | [...]              | (ideal) first on 16 or<br>17  | 344.166 -2.737 |
| 59                  | Obv. V 4'           | Arta II year 24 | VI   | 16            | first   | appearance in the | east | in | Libra              | (ideal) first on 14           | 174.897 0.885  |
| 59                  | Obv. V 5'           | Arta II year 24 | VIII | 22            | [last]  | appearance in the | east | in | Sagittarius        |                               | 213.769 0.233  |
| 59                  | Obv. V 6'           | Arta II year 24 | VIII | 30            | first   | appearance in the | west | in | Capricorn          |                               | 274.53 -1.889  |
| 59                  | Obv. V 7'           | Arta II year 24 | X    | 9             | first   | appearance in the | east | in | Capricorn          |                               | 279.96 2.591   |
| 59                  | Obv. V 9'           | Arta II year 24 | XI   | Around the 13 | last    | appearance in the | east | in | Aquarius           |                               | 312.28 -2.177  |
| 59                  | Obv. V 14'          | Arta II year 25 | II   | 29            | [first] | appearance in the | east |    | [...]              | (ideal) first on 25           | 54.273 -2.346  |
| 59                  | Obv. V 20'          | Arta II year 25 | VI   | 13            | [first] | appearance in the | east | in | Virgo              |                               | 158.315 0.587  |
| 59                  | Obv. V 23'          | Arta II year 25 | VII  | 8             | last    | appearance in the | east | in | Libra              |                               | 187.078 1.387  |
| 59                  | Obv. V 23'-<br>24'  | Arta II year 25 | VIII | 29            | first   | appearance in the | west | in | end of Sagittarius | (ideal) first on 24           | 265.526 -1.909 |
| 59                  | Obv. V 24'-<br>25'  | Arta II year 25 | IX   | 16            | last    | appearance in the | west | in | Capricorn          |                               | 278.129 1.709  |
| 59                  | Obv. V 25'-<br>26'  | Arta II year 25 | X    | 1             | first   | appearance in the | east | in | end of Sagittarius | (ideal) first on 27 of<br>IX  | 263.601 3.287  |
| 59                  | Obv. V 27'          | Arta II year 25 | XI   | Around the 9  | last    | appearance in the | east | in | Aquarius           |                               | 299.032 -1.957 |
| 59                  | Obv. V 28'          | Arta II year 25 | XII  | 12            | first   | appearance in the | west | in | Aries              | (ideal) first on 11           | 1.158 0.503    |
| 59                  | Obv. V 30'-<br>31'  | Arta II year 26 | I    | 15            | last    | appearance in the | west | in | Taurus             |                               | 33.793 1.115   |
| 59                  | Obv. V 31'          | Arta II year 26 | II   | 16            | first   | appearance in the | east |    | omitted            |                               | 29.624 -3.621  |
| 59                  | Obv. V 32'          | Arta II year 26 | III  | 3             | last    | appearance in the | east |    | omitted            |                               | 51.642 -0.975  |
| 59                  | Obv. V.<br>32'-33'  | Arta II year 26 | IV   | 6             | first   | appearance in the | west | in | Leo                | (ideal) first on 1            | 114.554 1.486  |

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|----------------------------|---------------------|-----------------|-----------------|-----------------|---------|-------------------|--------|----|-------------|-----------------------|----------------|
| 59                         | Rev. VI 3'          | Arta II year 27 | IV              | 7               | last    | appearance in the | west   | in | Leo         |                       | 140.249 -3.494 |
| 59                         | Rev. VI 4'          | Arta II year 27 | [V]             | [...]           | [first] | appearance in the | [east] |    | [...]       | (ideal) first on 1    | 126.342 -1.439 |
| 59                         | Rev. VI 4'-<br>5'   | Arta II year 27 | [V]             | 25              | [last]  | appearance in the | east   |    | [...]       |                       | 154.463 1.837  |
| 59                         | Rev. VI 6'          | Arta II year 27 | [VIII]          | 19 <sup>2</sup> | first   | appearance in the | east   | in | Scorpius    |                       | 231.124 3.157  |
| 59                         | Rev. VI 7'          | Arta II year 27 | IX <sup>2</sup> | 29 <sup>2</sup> | last    | appearance in the | east   | in | Capricorn   |                       | 273.316 -1.53  |
| 59                         | Rev. VI 7'-<br>8'   | Arta II year 27 | XI              | 3               | [first] | appearance in the | west   |    | [...]       |                       | 330.837 -0.387 |
| 59                         | Rev. VI 8'          | Arta II year 27 | XII             | 29              | first   | appearance in the | east   |    | omitted     |                       | 349.632 -2.69  |
| 59                         | Rev. VI 9'          | Arta II year 28 | II              | 19              | first   | appearance in the | west   |    | [...]       |                       | 72.901 1.878   |
| 59                         | Rev. VI 11'         | Arta II year 28 | IV              | 3               | last    | appearance in the | west   | in | Leo         |                       | 122.868 -3.586 |
| 59                         | Rev. VI 12'         | Arta II year 28 | IV              | 29              | first   | appearance in the | east   |    | [...]       | (ideal) first on 24   | 110.656 -0.995 |
| 59                         | Rev. VI 13'         | Arta II year 28 | V               | 20              | [last]  | appearance in the | east   |    | [...]       |                       | 141.252 1.84   |
| 59                         | Rev. VI 13'         | Arta II year 28 | VI <sup>2</sup> | 28              | [last]  | appearance in the | [west] |    | [...]       |                       | 202.836 -1.638 |
| 59                         | Rev. VI 14'         | Arta II year 28 | [VI]I           | 15              | first   | appearance in the | west   | in | Scorpius    |                       | 223.915 -2.602 |
| 59                         | Rev. VI 17'         | Arta II year 28 | XI              | 23              | [last]  | appearance in the | west   |    | [...]       |                       | 336.662 3.693  |
| 59                         | Rev. VI 19'         | Arta II year 29 | I               | 10              | last    | appearance in the | east   | in | Aries       |                       | 352.165 -2.642 |
| 59                         | Rev. VI 19'         | Arta II year 29 | II              | 14              | [first] | appearance in the | [west] |    | [...]       | (ideal) first on 10   | 57.106 1.746   |
| 59                         | Rev. VI 20'         | Arta II year 29 | III             | 27              | [last]  | appearance in the | west   |    | [...]       |                       | 104.509 -3.178 |
| 59                         | Rev. VI 21'         | Arta II year 29 | [IV]            | [...]           | first   | appearance in the | east   | in | Cancer      | (ideal) first on 21   | 93.025 -2.543  |
| 59                         | Rev. VI 22'         | Arta II year 29 | VII             | 7               | first   | appearance in the | west   |    | omitted     |                       | 206.808 -2.678 |
| 59                         | Rev. VI 22'         | Arta II year 29 | VII             | 21              | last    | appearance in the | west   |    | omitted     |                       | 214.946 -2.17  |
| 59                         | Rev. VI 22'-<br>23' | Arta II year 29 | [VIII]          | 7               | first   | appearance in the | east   | in | Libra       | (ideal) first on 6    | 199.772 2.131  |
| 59                         | Rev. VI 25'         | Arta II year 29 | IX              | 7               | last    | appearance in the | east   | in | Sagittarius |                       | 228.456 0.289  |
| 59                         | Rev. VI 27'         | Arta II year 29 | XI              | 14              | last    | appearance in the | west   | in | Aquarius    |                       | 320.814 3.37   |
| 59                         | Rev. VI 27'-<br>28' | Arta II year 29 | XII             | 8               | first   | appearance in the | east   | in | Aquarius    | (ideal) first on 4    | 308.574 0.297  |
| 63                         | Rev. 12             | Arta II year 41 | I               | 6               | first   | appearance in the | east   |    | omitted     |                       | 2.689 -3.035   |
| 63                         | Rev. 12             | Arta II year 41 | I               | 20              | last    | appearance in the | east   |    | omitted     |                       | 24.458 -1.591  |
| 63                         | Rev. 13             | Arta II year 41 | III             | 29              | last    | appearance in the | west   | in | Leo         |                       | 125.715 -3.645 |



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|----------------------------|---------------------|-----------------|------|-----------------|---------|-------------------|--------|----|------------------|--|-----------------------|----------|
| 63                         | Rev. 13-14          | Arta II year 41 | IV   | 27              | first   | appearance in the | east   | in | Leo              | (ideal) first on 21                        | 112.572               | -2.327   |
| 63                         | Rev. 14-15          | Arta II year 41 | V    | 18              | last    | appearance in the | east   | in | Virgo            |  | 144.105               | 1.833    |
| 63                         | Rev. 15             | Arta II year 41 | VII  | 8               | first   | appearance in the | west   |    | [...]            |  | 221.89                | -2.513   |
| 63                         | Rev. 15             | Arta II year 41 | VII  | 21              | last    | appearance in the | west   |    | [...]            |  | 233.332               | -1.872   |
| 63                         | Rev. 15-16          | Arta II year 41 | VIII | 10              | first   | appearance in the | east   | in | Scorpius         | (ideal) first on 8                         | 218.048               | 2.812    |
| 63                         | Rev. 17             | Arta II year 41 | IX   | 23              | last    | appearance in the | [east] | in | Sagittarius      |  | 264.997               | -1.467   |
| 63                         | Rev. 17             | Arta II year 41 | X    | 21              | first   | appearance in the | west   | in | Aquarius         |  | 314.09                | -1.089   |
| 63                         | Rev. 18             | Arta II year 41 | [XI] | 28              | last    | appearance in the | west   | in | Pisces           |  | 332.632               | 2.347    |
| 63                         | Rev. 18             | Arta II year 41 | XII  | 17              | first   | appearance in the | east   | in | Pisces           |  | 332.85                | -1.813   |
| 65                         | Obv.' I' 6          | Arta II year 43 | X    | 13              | first   | appearance in the | west   | in | end of Capricorn |  | 286.487               | -1.639   |
| 65                         | Obv.' I' 7          | Arta II year 43 | [XI] | 5               | last    | appearance in the | west   | in | Aquarius         |  | 306.246               | 3.135    |
| 65                         | Obv.' I' 7          | Arta II year 43 | [XI] | 20              | first   | appearance in the | east   | in | [Aquarius]       | (ideal) first on 16                        | 293.295               | 2.705    |
| 65                         | Obv.' I' 8          | Arta II year 43 | XII  | 27              | last    | appearance in the | east   | in | Pisces           |  | 327.235               | -2.375   |
| 65                         | Obv.' I' 9          | Arta II year 44 | I    | 2               | [first] | appearance in the | west   | in | Taurus           | (ideal) first on 25 of<br>XII <sub>2</sub> | 34.071                | 1.644    |
| 65                         | Obv.' I' 12         | Arta II year 44 | II   | 20              | last    | appearance in the | west   | in | [Gemini]         |  | 63.063                | -4.108   |
| 65                         | Obv.' I' 13         | Arta II year 44 | III  | 10              | first   | appearance in the | east   | in | Gemini           | (ideal) first on 6                         | 64.776                | -2.406   |
| 65                         | Obv.' I' 14         | Arta II year 44 | III  | 27              | last    | appearance in the | east   | in | Cancer           |  | 91.779                | 1.097    |
| 65                         | Obv.' I' 14-<br>15  | Arta II year 44 | V    | 2               | first   | appearance in the | west   | in | Virgo            | (ideal) first on 27 of<br>IV               | 153.208               | -0.018   |
| 65                         | Obv.' I' 15         | Arta II year 44 | V    | 27              | last    | appearance in the | west   | in | Virgo            |  | 182.981               | -3.106   |
| 65                         | Obv.' I' 15-<br>16  | Arta II year 44 | [VI] | 24 <sup>2</sup> | first   | appearance in the | [east] | in | Virgo            | (ideal) first on 21                        | 170.23                | 1.014    |
| 65                         | Obv.' I' 17-<br>18  | Arta II year 44 | VII  | 26              | [last]  | appearance in the | east   |    | [...]            |  | 207.627               | 0.506    |
| 65                         | Obv.' I' 18         | Arta II year 44 | [IX] | 6               | first   | appearance in the | west   | in | Capricorn        |  | 269.554               | -1.994   |
| 65                         | Obv.' I' 19         | Arta II year 44 | X    | 12              | [first] | appearance in the | east   |    | [...]            |  | 277.09                | 3.452    |
| 65                         | Obv.' I' 20         | Arta II year 44 | XI   | 25              | [last]  | appearance in the | east   |    | [...]            |  | 317.14                | -2.238   |
| 65                         | Obv.' II' 3'        | Arta III year 3 | III  | 5               | last    | appearance in the | west   | in | Cancer           |  | 99.228                | -3.399   |
| 65                         | Obv.' II' 3'        | Arta III year 3 | III  | 28              | [first] | appearance in the | [east] |    | [...]            |  | 88.743                | -2.602   |
| 65                         | Obv.' II' 4'        | Arta III year 3 | IV   | 19              | last    | appearance in the | east   | in | Leo              |  | 116.939               | 1.633    |

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|---------------------|---------------------|-----------------|------------------|---------------|---------|-------------------|--------|---------------------------|-----------------------|----------|
| 65                  | Obv.' II' 5'        | Arta III year 3 | [VI]             | 23            | last    | appearance in the | west   | omitted                   | 200.032               | -2.504   |
| 65                  | Obv.' II' 6'        | Arta III year 3 | VII              | 21            | [last]  | appearance in the | east   | in beginning of Capricorn | 198.98                | 1.015    |
| 65                  | Obv.' II' 7'        | Arta III year 3 | X                | 21            | last    | appearance in the | west   | in end of Aquarius        | 315.576               | 3.518    |
| 65                  | Obv.' II' 8'        | Arta III year 3 | XII              | 10            | [last]  | appearance in the | east   | in Pisces                 | 331.54                | -2.471   |
| 65                  | Obv.' II' 9'        | Arta III year 4 | I                | Around the 3  | first   | appearance in the | west   | in Taurus                 | 11.863                | -0.559   |
| 65                  | Obv.' II' 11'       | Arta III year 4 | II               | Around the 27 | last    | appearance in the | west   | in Cancer                 | 79.87                 | -2.512   |
| 65                  | Obv.' II' 12'       | Arta III year 4 | III              | Around the 24 | first   | appearance in the | east   | in Gemini                 | 72.899                | -2.59    |
| 65                  | Obv.' II' 13'       | Arta III year 4 | IV               | 14            | [last]  | appearance in the | east   | in Cancer                 | 101.223               | 1.335    |
| 65                  | Obv.' II' 14'       | Arta III year 4 | V                | Around the 28 | first   | appearance in the | west   | in Libra                  | 175.689               | -1.506   |
| 65                  | Obv.' II' 15'       | Arta III year 4 | VII              | Around the 9  | first   | appearance in the | east   | in Libra                  | 179.767               | 1.258    |
| 65                  | Obv.' II' 16'       | Arta III year 4 | VIII             | 12            | last    | appearance in the | east   | in Scorpius               | 215.937               | 0.31     |
| 65                  | Obv.' II' 17'       | Arta III year 4 | X                | 14            | last    | appearance in the | west   | in Aquarius               | 299.677               | 2.721    |
| 65                  | Obv.' II' 26'       | Arta III year 5 | IX               | 18            | [first] | appearance in the | west   | in end of Sagittarius     | 265.027               | -2.039   |
| 65                  | Obv.' II' 26'       | Arta III year 5 | X                | 8             | last    | appearance in the | west   | in Capricorn              | 283.65                | 1.773    |
| 65                  | Obv.' II' 27'       | Arta III year 5 | XII              | 5             | last    | appearance in the | east   | in Aquarius               | 309.429               | -2.161   |
| 65                  | Obv.' II' 27'       | Arta III year 5 | XII <sub>2</sub> | 4             | [first] | appearance in the | west   | [...]                     | 5.283                 | 0.559    |
| 65                  | Obv.' II' 28'       | Arta III year 6 | I                | 10            | last    | appearance in the | west   | in Taurus                 | 39.99                 | 0.504    |
| 65                  | Obv.' II' 28'       | Arta III year 6 | II               | 14            | first   | appearance in the | east   | omitted                   | 40.145                | -2.995   |
| 65                  | Obv.' II' 28'-29'   | Arta III year 6 | II               | 25            | last    | appearance in the | east   | omitted                   | 55.87                 | -0.925   |
| 65                  | Obv.' II' 29'       | Arta III year 6 | III              | Around the 23 | first   | appearance in the | west   | in Leo                    | 111.311               | 1.693    |
| 65                  | Obv.' II' 29'       | Arta III year 6 | V                | 4             | [last]  | appearance in the | west   | in Virgo                  | 161.464               | -3.294   |
| 65                  | Obv.' II' 30'       | Arta III year 6 | VI               | 1             | first   | appearance in the | east   | in Virgo                  | 147.535               | 0.408    |
| 65                  | Obv.' II' 31'       | Arta III year 6 | VI               | 27            | last    | appearance in the | east   | in beginning of Libra     | 181.381               | 1.314    |
| 65                  | Obv.' II' 31'       | Arta III year 6 | VIII             | Around the 12 | [first] | appearance in the | west   | in [Capricorn]            | 250.053               | -2.229   |
| 65                  | Obv.' II' 32'       | Arta III year 6 | IX               | 2             | last    | appearance in the | west   | in Capricorn              | 267.716               | 0.744    |
| 65                  | Obv.' II' 33'       | Arta III year 6 | XII              | Around the 1  | [first] | appearance in the | west   | in Pisces                 | 353.086               | 0.41     |
| 65                  | Obv.' II' 34'       | Arta III year 7 | I                | 1             | last    | appearance in the | west   | in Taurus                 | 20.202                | 1.99     |
| 65                  | Obv.' II' 34'       | Arta III year 7 | II               | 6             | first   | appearance in the | east   | omitted                   | 20.088                | -3.331   |
| 65                  | Obv.' II' 34'       | Arta III year 7 | II               | 20+x          | [last]  | appearance in the | [east] | [omitted]                 | 39.809                | -1.421   |

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|----------------------------|---------------------|------------------|---------------------|-----------------|---------|-------------------|--------|----|---------------------|-----------------------|----------|
| 65                         | Obv.' II' 35'       | Arta III year 7  | III                 | 15              | first   | appearance in the | west   | in | Cancer              | 90.426                | 1.865    |
| 65                         | Obv.' II' 36'       | Arta III year 7  | IV                  | 28              | [last]  | appearance in the | west   | in | be[ginning of ...]  | 145.539               | -3.425   |
| 65                         | Obv.' II' 37'       | Arta III year 7  | V                   | Around the 21   | first   | appearance in the | east   | in | Leo                 | 132.178               | -1.693   |
| 65                         | Obv.' II' 37'       | Arta III year 7  | VI                  | 16              | [last]  | appearance in the | east   |    | [...]               | 157.789               | 1.855    |
| 65                         | Obv.' II' 38'       | Arta III year 7  | [VIII]              | 26              | last    | appearance in the | west   | in | Sagittarius         | 251.809               | -0.228   |
| 65                         | Obv.' II' 39'       | Arta III year 7  | X                   | 24              | last    | appearance in the | east   | in | Capricorn           | 280.292               | -1.716   |
| 65                         | Obv.' II' 41'       | Arta III year 8  | II                  | 1               | first   | appearance in the | east   |    | omitted             | 3.223                 | -3.122   |
| 65                         | Obv.' II' 41'       | Arta III year 8  | II                  | 17              | last    | appearance in the | east   |    | omitted             | 27.453                | -1.495   |
| 65                         | Obv.' II' 1"        | Arta III year 9  | II                  | 5               | [first] | appearance in the | west   | in | Gemini              | 59.077                | 1.667    |
| 65                         | Obv.' II' 3"        | Arta III year 9  | V                   | 4               | last    | appearance in the | east   | in | behind alpha Leonis | 124.306               | 1.71     |
| 65                         | Obv.' II' 4"        | Arta III year 9  | VII                 | 12 <sup>2</sup> | last    | appearance in the | west   |    | omitted             | 220.152               | -2.361   |
| 65                         | Obv.' II' 4"        | Arta III year 9  | VII                 | Around the 27   | first   | appearance in the | east   | in | Libra               | 206.911               | 1.82     |
| 65                         | Obv.' II' 6"        | Arta III year 9  | IX                  | 10              | [last]  | appearance in the | [east] |    | [...]               | 247.345               | -0.877   |
| 65                         | Obv.' II' 7"        | Arta III year 9  | XI                  | 7               | [last]  | appearance in the | west   | in | Pisces              | 326.222               | 3.496    |
| 65                         | Obv.' II' 8"        | Arta III year 9  | XI                  |                 | first   | appearance in the | [east] | in | Aquarius            | 313.693               | 1.432    |
| 65                         | Rev.' I 1           | Arta III year 10 | IV                  | 9               | first   | appearance in the | east   | in | beginning of Cancer | 82.13                 | -2.533   |
| 65                         | Rev.' I 2           | Arta III year 10 | IV <sup>2</sup>     | 28              | last    | appearance in the | east   | in | Leo                 | 108.649               | 1.44     |
| 65                         | Rev.' I 3           | Arta III year 10 | VII                 | 1               | last    | appearance in the | west   |    | omitted             | 202.35                | -3.028   |
| 65                         | Rev.' I 3           | Arta III year 10 | VII                 | Around the 23   | first   | appearance in the | east   | in | Libra               | 189.431               | 1.504    |
| 65                         | Rev.' I 4           | Arta III year 10 | [VIII]              | 30              | last    | appearance in the | east   | in | Scorpius            | 227.277               | -0.12    |
| 65                         | Rev.' I 5-6         | Arta III year 10 | X                   | Around the 11   | first   | appearance in the | west   | in | Capricorn           | 292.782               | -1.33    |
| 65                         | Rev.' I 6           | Arta III year 10 | XI                  | 1               | last    | appearance in the | west   | in | Aquarius            | 308.857               | 3.241    |
| 65                         | Rev.' I 6           | Arta III year 10 | XI                  | Around the 15   | first   | appearance in the | east   | in | Pisces              | 296.498               | 2.816    |
| 65                         | Rev.' I 7           | Arta III year 10 | XII                 | 20              | last    | appearance in the | east   | in | Pisces              | 323.744               | -2.358   |
| 65                         | Rev.' I 7           | Arta III year 10 | XII <sub>2</sub>    | 27              | first   | appearance in the | west   | in | Taurus              | 33.153                | 1.45     |
| 65                         | Rev.' I 9           | Arta III year 11 | III                 | Around the 5    | first   | appearance in the | east   | in | Gemini              | 65.922                | -2.74    |
| 65                         | Rev.' I 10          | Arta III year 11 | III <sup>2</sup>    | 23              | [last]  | appearance in the | [east] |    | [...]               | 92.801                | 1.057    |
| 65                         | Rev.' I 10-11       | Arta III year 11 | V                   | Around the 20   | [last]  | appearance in the | west   |    | [...]               | 182.345               | -2.749   |
| 65                         | Rev.' I 6           | Arta III year 12 | [VII <sup>2</sup> ] | 13 <sup>2</sup> | last    | appearance in the | east   | in | Libra               | 188.261               | 1.26     |

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|---------------------|---------------------|---------------------|------------------|-----------------|---------|-------------------|--------|----|-------------|------------------------------------|----------|
| 65                  | Rev.' I 9'          | Arta III year 12    | XII              | 15              | [first] | appearance in the | west   | in | Aries       | 0.728                              | 0.547    |
| 65                  | Rev.' I 11'         | Arta III year 13    | II               | 19              | first   | appearance in the | east   |    | omitted     | 27.538                             | -3.628   |
| 65                  | Rev.' I 13'         | Arta III year 13    | VI <sup>2</sup>  | 9               | first   | appearance in the | east   | in | Virgo       | 141.178                            | -0.833   |
| 65                  | Rev.' I 14'         | Arta III year 13    | VIII             | 28              | first   | appearance in the | west   | in | Sagittarius | 250.994                            | -2.164   |
| 65                  | Rev.' I 15'         | Arta III year 13    | IX <sup>2</sup>  | Around the 22   | [first] | appearance in the | east   | in | Sagittarius | 250.397                            | 3.165    |
| 65                  | Rev.' I 16'         | Arta III year 13    | XII              | 10              | [first] | appearance in the | west   | in | Pisces      | 344.535                            | 0.008    |
| 65                  | Rev.' I 18'         | Arta III year 13    | XII <sub>2</sub> | 12              | [last]  | appearance in the | west   | in | Aries       | 10.998                             | 2.061    |
| 65                  | Rev.' I 21'         | Arta III year 14    | IV               | 12              | [last]  | appearance in the | west   | in | [Leo]       | 138.713                            | -3.737   |
| 65                  | Rev.' I 21'-<br>22' | Arta III year 14    | V                | 29              | last    | appearance in the | east   | in | Virgo       | 154.057                            | 1.821    |
| 65                  | Rev.' I 24'         | Arta III year 14    | XI               | Around the 4    | [first] | appearance in the | west   |    | [...]       | 326.515                            | -0.697   |
| 65                  | Rev.' I 26'         | Arta III year 15    | I                | 2               | first   | appearance in the | east   |    | omitted     | 347.55                             | -2.577   |
| 65                  | Rev.' I 29'         | Arta III year 15    | IV               | 15              |         | appearance in the | west   |    | [...]       | 116.352                            | -4.622   |
| 65                  | Rev.' I 32'         | Arta III year 15    | V <sup>2</sup>   | 22              | last    | appearance in the | east   | in | Leo         | 133.496                            | 1.817    |
| 65                  | Rev.' I 33'         | Arta III year 15    | VIII             | 19              | first   | appearance in the | east   | in | Scorpius    | 213.233                            | 2.832    |
| 65                  | Rev.' I 35'         | Arta III year 15    | IX <sup>2</sup>  | 27              | last    | appearance in the | east   | in | Sagittarius | 257.209                            | -1.164   |
| 65                  | Rev.' I 35'-<br>36' | Arta III year 15    | [XI]             | 25              | [last]  | appearance in the | west   | in | Pisces      | 335.628                            | 3.689    |
| 65                  | Rev.' I 37'         | Arta III year 16    | I                | 11              | [last]  | appearance in the | east   | in | Aries       | 346.976                            | -2.705   |
| 67                  | II' 2'              | SE 6                | V                | 24              | [first] | appearance in the | east   |    | [...]       | 132.539                            | -0.456   |
| 67                  | II' 2'-3'           | 6                   | VIII             | 25              | last    | appearance in the | west   | in | Sagittarius | 252.56                             | 0.039    |
| 67                  | II' 4'-5'           | 6                   | IX               | 11 <sup>2</sup> | [first] | appearance in the | east   |    | [...]       | (ideal) first on 8 or 9<br>237.275 | 3.231    |
| 67                  | II' 6'              | 6                   | XI               | 25              | [first] | appearance in the | [west] |    | [...]       | (ideal) first on 22<br>339.469     | 0.03     |
| 67                  | II' 8'              | 6                   | XII              | 23              | [last]  | appearance in the | west   | in | Aries       | 2.019                              | 2.992    |
| 67                  | II' 13'             | 7                   | II <sup>2</sup>  | 1               | first   | appearance in the | east   |    | omitted     | 5.209                              | -3.109   |
| 67                  | II' 13'             | 7                   | II               | 17              | last    | appearance in the | east   |    | omitted     | 29.98                              | -1.349   |
| 67                  | II' 13'             | 7                   | III              | 12              | first   | appearance in the | west   | in | Cancer      | (ideal) first on 10<br>79.487      | 1.902    |
| 67                  | II' 16'             | 7                   | V                | 20              | first   | appearance in the | east   | in | Leo         | 116.615                            | -0.961   |
| 67                  | II' 17'             | 7                   | VIII             | 14              | [last]  | appearance in the | west   | in | Scorpius    | 236.132                            | -2.057   |
| 67                  | II' 18'             | 7                   | X <sup>2</sup>   | 16              | last    | appearance in the | [east] | in | Scorpius    | 265.158                            | -1.362   |
| 68                  | B 3'                | 7                   | IX               | 4               | [first] | appearance in the | [east] |    | [...]       | (ideal) first on 3<br>221.654      | 2.894    |

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|---------------------|----------------|---------------------|--------------------|----------------|---------|-------------------|--------|----|-----------------------|--------------------------|---------|----------|
| 68                  | B 4'           | 7                   | X                  | 17             | last    | appearance in the | east   | in | end of Sagittarius    |                          | 263.586 | -1.276   |
| 68                  | B 4'-5'        | 7                   | XI                 | [...]          | first   | appearance in the | west   | in | Aquarius              | (ideal) first on 16      | 315.809 | -1.146   |
| 68                  | B 5'           | 7                   | XII                | 14             | [last]  | appearance in the | west   | in | Pisces                |                          | 344.166 | 3.618    |
| 68                  | B 6'           | 7                   | XII <sub>2</sub>   | 18             | first   | appearance in the | east   | in | Pisces                | (ideal) first on 14      | 340.893 | -2.515   |
| 68                  | B 6'           | 7                   | XII <sub>2</sub>   | 29             | [last]  | appearance in the | east   |    | [...]                 |                          | 354.222 | -2.79    |
| 68                  | B 7'           | 8                   | II                 | 6              | first   | appearance in the | west   | in | Gemini                | (ideal) first on 4       | 63.776  | 1.822    |
| 68                  | B 8'           | 8                   | III                | 20             | last    | appearance in the | west   | in | Cancer                |                          | 111.433 | -3.54    |
| 68                  | B 8'           | 8                   | IV                 | 15             | first   | appearance in the | east   | in | Cancer                |                          | 100.243 | -1.696   |
| 68                  | B 9'           | 8                   | V                  | 3 or 4         | last    | appearance in the | east   | in | Leo                   |                          | 123.085 | 1.643    |
| 68                  | B 9'-10'       | 8                   | VI                 | 26             | first   | appearance in the | [west] |    | omitted               |                          | 208.189 | -2.44    |
| 68                  | B 12'          | 8                   | X                  | 15             | first   | appearance in the | west   | in | beginning of Aquarius | (ideal) first on 10+x    | 309.237 | -0.871   |
| 68                  | B 13'          | 8                   | XI                 | 7              | last    | appearance in the | west   | in | beginning of Pisces   |                          | 326.931 | 3.597    |
| 68                  | B 13'          | 8                   | XI                 | 27             | first   | appearance in the | east   | in | Aquarius              |                          | 314.702 | 0.72     |
| 68                  | B 14'          | 8                   | XII                | Around the 25  | last    | appearance in the | east   | in | end of Pisces         |                          | 341.423 | -2.585   |
| 68                  | B 15'          | 9                   | II                 | 2              | first   | appearance in the | west   | in | beginning of Gemini   | (ideal) first on 29 of I | 49.866  | 1.725    |
| 68                  | B 17'          | 9                   | IV                 | 10             | first   | appearance in the | east   | in | Cancer                |                          | 83.636  | -2.312   |
| 68                  | B 18'          | 9                   | IV                 | 28             | last    | appearance in the | east   | in | Cancer                |                          | 109.289 | 1.429    |
| 68                  | B 18'          | 9                   | VI                 | 20             | [first] | appearance in the | west   |    | [omitted]             |                          | 192.474 | -2.295   |
| 68                  | B 19'          | 9                   | [VII]              | 25             | first   | appearance in the | east   | in | Libra                 |                          | 189.581 | 1.906    |
| 68                  | B 21'          | 9                   | VIII <sup>2</sup>  | 30             | [last]  | appearance in the | east   | in | end [of Scorpius]     |                          | 229.497 | -0.223   |
| 68                  | B 22'          | 9                   | XI                 | 1              | [last]  | appearance in the | west   |    | [...]                 |                          | 309.396 | 3.399    |
| 70                  | Rev. II 23'    | 46                  | I                  | 22             | first   | appearance in the | east   |    | omitted               |                          | 16.502  | -3.016   |
| 70                  | Rev. II 24'    | 46                  | III                | 1              | first   | appearance in the | west   | in | Cancer                |                          | 88.347  | 1.906    |
| 70                  | Rev. II 25'    | 46                  | IV                 | 13             | last    | appearance in the | west   | in | Leo                   |                          | 137.969 | -3.489   |
| 70                  | Rev. II 26'    | 46                  | V                  | [...]          | first   | appearance in the | east   | in | Leo                   | (ideal) first on 4       | 124.907 | -2.269   |
| 70                  | Rev. III 2'    | 48                  | [IV <sup>2</sup> ] | 18             | last    | appearance in the | east   | in | Leo                   |                          | 119.508 | 1.663    |
| 70                  | Rev. III 2'    | 48                  | VI                 | 9 <sup>2</sup> | first   | appearance in the | west   |    | omitted               |                          | 200.381 | -2.397   |
| 70                  | Rev. III 5'-6' | 48                  | X                  | 19             | last    | appearance in the | west   | in | Aquarius              |                          | 318.482 | 3.299    |
| 70                  | Rev. III 6'    | 48                  | XI                 | 10             | first   | appearance in the | east   | in | Aquarius              | (ideal) first on 7       | 305.214 | 1.337    |

| ADART Vol. V<br>No. |                    | Observation<br>date |        |                            |         |                   |        |    |                     |                     | Tropical<br>Longitude | Latitude |
|---------------------|--------------------|---------------------|--------|----------------------------|---------|-------------------|--------|----|---------------------|---------------------|-----------------------|----------|
| 70                  | Rev. III 7'        | 48                  | XII    | 10                         | last    | appearance in the | east   | in | Pisces              |                     | 334.514               | -2.487   |
| 70                  | Rev. III 8'        | 49                  | I      | 12 <sup>2</sup>            | first   | appearance in the | [west] | in | Taurus              |                     | 36.82                 | 1.262    |
| 70                  | Rev. III 22'       | 50                  | I      | 7                          | [first] | appearance in the | west   | in | Taurus              |                     | 20.652                | 0.83     |
| 71                  | 'Obv. I 2'-3'      | 14                  | II     | 22 <sup>2</sup>            | [first] | appearance in the | west   | in | [Gemini]            |                     | 73.156                | 1.889    |
| 71                  | 'Obv. I 6'         | 14                  | IV     | 4                          | last    | appearance in the | west   | in | Leo                 |                     | 122.186               | -3.467   |
| 71                  | 'Obv. I 9'-<br>10' | 14                  | VIII   | 13                         | [first] | appearance in the | east   |    | [...]               |                     | 216.297               | 2.445    |
| 71                  | 'Obv. II 1'        | 16                  | VI     | 9                          | [last]  | appearance in the | [west] | in | Libra               |                     | 195.486               | -3.035   |
| 71                  | 'Obv. II 4'        | 16                  | [X]    | 25                         | [first] | appearance in the | east   | in | Capricorn           |                     | 290.083               | 2.947    |
| 71                  | 'Obv. II 6'        | 17                  | I      | 6                          | [first] | appearance in the | west   | in | [Taurus]            |                     | 25.197                | 1.127    |
| 73                  | 'Obv. I 8'         | 54                  | [IX]   | 9                          | [last]  | appearance in the | east   |    | ...                 |                     | 250.259               | -0.961   |
| 73                  | 'Obv. I 16'        | 55                  | I      | Around the 29              | first   | appearance in the | west   | in | Gemini              |                     | 48.469                | 1.6      |
| 73                  | 'Obv. I 20'        | 55                  | III    | 14 or around<br>the 10     | last    | appearance in the | west   | in | Cancer              |                     | 92.942                | -3.459   |
| 73                  | 'Obv. I 22'        | 55                  | IV     | 7                          | [first] | appearance in the | east   |    | [...]               |                     | 84.057                | -2.609   |
| 73                  | Obv. I 23'         | 55                  | [IV]   | 28                         | last    | appearance in the | east   | in | Leo                 |                     | 113.832               | 1.592    |
| 73                  | 'Obv. I 27'        | 55                  | VII    | [...]                      | first   | appearance in the | [east] | in | Libra               | (ideal) first on 22 | 191.795               | 1.452    |
| 73                  | Rev. III 6         | 55                  | [VIII] | 29                         | last    | appearance in the | east   | in | Scorpius            |                     | 228.64                | -0.101   |
| 73                  | Rev. III 7         | 55                  | X      | 12                         | first   | appearance in the | west   | in | end of Capricorn    | (ideal) first on 9  | 299.091               | -0.916   |
| 73                  | Rev. III 9         | 55                  | XI     | 1                          | last    | appearance in the | west   | in | Aquarius            |                     | 310.603               | 3.371    |
| 73                  | Rev. III 10        | 55                  | XI     | 25 <sup>2</sup>            | first   | appearance in the | east   |    | [...]               |                     | 299.547               | 0.419    |
| 73                  | Rev. III 11        | 55                  | XII    | 19                         | last    | appearance in the | east   |    | [...]               |                     | 326.705               | -2.39    |
| 73                  | Rev. III 17-<br>18 | 56                  | III    | 4                          | last    | appearance in the | west   | in | Gemini              |                     | 73.918                | -1.985   |
| 73                  | Rev. III 18-<br>19 | 56                  | IV     | 6                          | first   | appearance in the | [east] | in | [Gemini]            |                     | 70.368                | -2.121   |
| 73                  | Rev. III 19        | 56                  | IV     | 23                         | [last]  | appearance in the | east   |    | [...]               |                     | 96.065                | 1.161    |
| 73                  | Rev. IV 6-7        | 56                  | XI     | Around the 16 <sup>2</sup> | last    | appearance in the | east   | in | Aquarius            |                     | 314.737               | -2.207   |
| 73                  | Rev. IV 7-9        | 56                  | XII    | 22                         | first   | appearance in the | west   | in | beginning of Taurus | (ideal) first on 20 | 24.174                | 1.495    |
| 76                  | Obv. 5'            | 83                  | VIII   | Around the 4               | last    | appearance in the | east   | in | Libra               |                     | 195.001               | 1.157    |
| 76                  | Obv. 6'            | 83                  | X      | 10                         | last    | appearance in the | west   | in | Capricorn           |                     | 284.084               | 1.775    |

| ADART Vol. V |              | Observation |                     |                |                   |                   |                   |    |                                       | Tropical                  | Latitude |        |
|--------------|--------------|-------------|---------------------|----------------|-------------------|-------------------|-------------------|----|---------------------------------------|---------------------------|----------|--------|
| No.          |              | date        |                     |                |                   |                   |                   |    |                                       | Longitude                 |          |        |
| 76           | Obv. 8'      | 83          | [XII]               | Around the 7   | last              | appearance in the | east              | in | Aquarius                              | 310.328                   | -2.158   |        |
| 76           | Obv. 8'      | 83          | XII <sub>2</sub>    | 6              | first             | appearance in the | west              | in | Aries                                 | 6.122                     | 0.556    |        |
| 76           | Obv. 10'     | 84          | I                   | 10 or 11       | last              | appearance in the | west              | in | Taurus                                | 40.354                    | 0.748    |        |
| 76           | Obv. 10'-11' | 84          | II                  | 20             | first             | appearance in the | east              | in | Taurus                                | (ideal) first on 18       | 45.707   | -2.309 |
| 76           | Obv. 11'     | 84          | II                  | Around the 30  | last              | appearance in the | east              | in | Gemini                                | 62.214                    | -0.318   |        |
| 76           | Obv. 11'     | 84          | IV                  | 1              | [first]           | appearance in the | west              | in | beginning of Leo                      | 121.071                   | 1.357    |        |
| 76           | Obv. 12'     | 84          | V                   | 1              | last              | appearance in the | west              | in | end <sup>2</sup> of Leo               | 159.727                   | -2.782   |        |
| 76           | Obv. 12'     | 84          | VI                  | 3              | first             | appearance in the | [east]            | in | Virgo                                 | 148.115                   | 0.401    |        |
| 76           | Obv. 13'     | 84          | VIII                | 19             | first             | appearance in the | west              | in | Sagittarius                           | 258.055                   | -2.047   |        |
| 76           | Obv. 15'     | 84          | XII                 | 4              | first             | appearance in the | west              | in | beginning of Aries                    | (ideal) first on 2        | 355.857  | 0.603  |
| 76           | Obv. 17'     | 85          | I                   | 3              | last              | appearance in the | west              | in | beginning of Taurus                   | 20.287                    | 1.985    |        |
| 76           | Obv. 17'     | 85          | II                  | 13             | first             | appearance in the | east              |    | omitted                               | 26.644                    | -2.833   |        |
| 76           | Obv. 18'     | 85          | III                 | 19             | first             | appearance in the | west              | in | Cancer                                | 95.21                     | 1.872    |        |
| 76           | Obv. 19'     | 85          | V                   | 3              | last              | appearance in the | west              | in | end of Leo                            | 146.363                   | -3.752   |        |
| 76           | Obv. 19'-20' | 85          | V                   | 27             | first             | appearance in the | east              | in | Leo                                   | (ideal) first on 24       | 132.049  | -0.523 |
| 76           | Obv. 21'     | 85          | VIII                | [...]          | first             | appearance in the | west              | in | Sagittarius                           | (ideal) first on 14       | 244.107  | -2.305 |
| 76           | Obv. 22'     | 85          | VIII                | Around the 29  | last              | appearance in the | [west]            | in | Sagittarius                           | 251.302                   | 0.391    |        |
| 76           | Obv. 22'     | 85          | IX                  | 12             | first             | appearance in the | east              | in | beginning of Sagittarius <sup>2</sup> | 237.597                   | 3.208    |        |
| 76           | Obv. 23'     | 85          | XI                  | 29             | [first]           | appearance in the | west              | in | Pisces                                | (ideal) first on 27       | 341.516  | 0.248  |
| 76           | Obv. 24'     | 85          | [XII <sup>2</sup> ] | 6 <sup>2</sup> | last              | appearance in the | west              | in | Aries                                 | 351.654                   | 1.503    |        |
| 81           | I' 1'        | 138         | II <sup>2</sup>     | 4 <sup>2</sup> | last <sup>2</sup> | appearance in the | east <sup>2</sup> |    | omitted <sup>2</sup>                  | 40.322                    | -1.068   |        |
| 81           | I' 2'        | 138         | III                 | [...]          | first             | appearance in the | west              |    | [...]                                 | (ideal) first on 28 of II | 89.624   | 1.899  |
| 81           | I' 6'        | 138         | IV                  | Around the 10  | last              | appearance in the | west              | in | Leo                                   | 140.039                   | -3.438   |        |
| 81           | I' 7'-8'     | 138         | [V]                 | [...]          | [first]           | appearance in the | east              | in | Leo                                   | (ideal) first on 5        | 126.256  | -1.398 |
| 81           | I' 9'-10'    | 138         | VIII                | 1              | first             | appearance in the | west              | in | Sagittarius                           | 245.382                   | -1.866   |        |
| 81           | I' 10'       | 138         | VIII                | 11             | [last]            | appearance in the | west              |    | [...]                                 | 243.979                   | 0.661    |        |
| 81           | II' 4'       | 139         | [IV <sup>2</sup> ]  | Around the 6   | last              | appearance in the | west              | in | Leo                                   | 122.563                   | -3.51    |        |
| 81           | II' 4'-5'    | 139         | V                   | 6 <sup>2</sup> | [first]           | appearance in the | east              |    | [...]                                 | (ideal) first on 1        | 112.417  | -0.404 |

| ADART Vol. V |              | Observation      |                  |                 |         |                   |        |                                       |                            | Tropical  |  | Latitude |
|--------------|--------------|------------------|------------------|-----------------|---------|-------------------|--------|---------------------------------------|----------------------------|-----------|--|----------|
| No.          |              | date             |                  |                 |         |                   |        |                                       |                            | Longitude |  |          |
| 81           | II' 5'       | 139              | V                | 25              | last    | appearance in the | east   | [...]                                 |                            | 142.438   |  | 1.829    |
| 81           | II' 6'       | 139              | VII              | 17              | first   | appearance in the | west   | omitted                               |                            | 222.503   |  | -2.62    |
| 81           | II' 7'       | 139              | VIII             | 17              | first   | appearance in the | east   | in Scorpius                           | (ideal) first on 13        | 215.025   |  | 2.769    |
| 81           | II' 10'      | 139              | IX <sup>2</sup>  | [...]           | last    | appearance in the | east   | in Sagittarius                        | from the 26 did not see it | 257.284   |  | -1.069   |
| 81           | II' 14'      | 140              | [I]              | 14 <sup>2</sup> | last    | appearance in the | east   | in Aries                              |                            | 351.51    |  | -2.653   |
| 81           | II' 14'      | 140              | II <sup>2</sup>  | 17              | [first] | appearance in the | west   | [...]                                 |                            | 56.187    |  | 1.667    |
| 81           | II' 18'-19'  | 140              | IV <sup>2</sup>  | 27              | [first] | appearance in the | east   | in Cancer                             | (ideal) first on 25        | 93.961    |  | -1.938   |
| 81           | II' 20'      | 140              | [V]              | Around the 17   | last    | appearance in the | east   | in beginning of Leo                   |                            | 121.432   |  | 1.672    |
| 81           | II' 21'      | 140              | VII              | 9               | first   | appearance in the | west   | omitted                               |                            | 204.293   |  | -2.534   |
| 81           | II' 21'      | 140              | VII              | 24 <sup>2</sup> | last    | appearance in the | west   | omitted                               |                            | 215.191   |  | -2.497   |
| 81           | II' 24'-25'  | 140              | IX               | Around the 21   | last    | appearance in the | east   | in Sagittarius                        |                            | 243.342   |  | -0.753   |
| 81           | II' 26'      | 140              | X <sup>2</sup>   |                 | [first] | appearance in the | [west] | [...]                                 | (ideal) first on 25        | 300.144   |  | -1.343   |
| 81           | II' 26'      | 140              | [XI]             | Around the 18   | [last]  | appearance in the | west   | in end of Aquarius                    |                            | 320.319   |  | 3.415    |
| 81           | II' 27'      | 140              | XII <sup>2</sup> | Around the 7    | first   | appearance in the | east   | in Aquarius                           |                            | 307.352   |  | 1.389    |
| 81           | II' 28'      | 140              | XII <sub>2</sub> | 10              | last    | appearance in the | east   | [...]                                 | from the 5 did not see it  | 339.096   |  | -2.483   |
| 81           | II' 29'      | 141              | I                | 15 <sup>2</sup> | first   | appearance in the | west   | in Taurus                             | (ideal) first on 13        | 46.218    |  | 1.747    |
| 81           | III' 13'-14' | 142              | II               | 13              | last    | appearance in the | west   | in Gemini                             |                            | 65.111    |  | -0.431   |
| 81           | III' 16'     | 142              | V                | [...]           | first   | appearance in the | [west] | [...]                                 | (ideal) first on 10        | 151.73    |  | 0.039    |
| 81           | III' 17'     | 142              | VII              | 3               | first   | appearance in the | east   | [...]                                 | (ideal) first on 30 of VI  | 167.542   |  | 1.092    |
| 84           | Line 4'      | 258 <sup>2</sup> | [IX]             | 9               | last    | appearance in the | east   | in Sagittarius                        |                            | 243.801   |  | -0.458   |
| 84           | Line 4'-5'   | 258 <sup>2</sup> | X                | 15              | first   | appearance in the | west   | in beginning of Aquarius              | (ideal) first on 13        | 303.758   |  | -1.431   |
| 84           | Line 5'      | 258 <sup>2</sup> | XI               | 6               | [last]  | appearance in the | west   | in beginning <sup>2</sup> of Aquarius |                            | 328.81    |  | 2.972    |
| 84           | Line 6'      | 258 <sup>2</sup> | XI               | x+18            | first   | appearance in the | east   | in beginning of Pisces                | (ideal) first on 15        | 315.324   |  | 1.161    |
| 84           | Line 7'      | 258 <sup>2</sup> | XII              | Around the 25   | last    | appearance in the | east   | in Pisces                             |                            | 337.114   |  | -2.549   |
| 84           | Line 8'      | 259 <sup>2</sup> | II               | 2               | first   | appearance in the | west   | in Gemini                             | (ideal) first on 1         | 47.521    |  | 1.497    |



### Appendix K3: Mercury phenomena from the Goal-Year Texts (ADART Vol. VI)

| ADART Vol. VI<br>No. |                | Observation date<br>(Seleucid Era) |                  |                |         |                   |        |       | Tropical<br>Longitude | Latitude                       |         |        |
|----------------------|----------------|------------------------------------|------------------|----------------|---------|-------------------|--------|-------|-----------------------|--------------------------------|---------|--------|
| 1                    | A 3'           | [30]                               | XII              | 29             | [first] | appearance in the | [west] | [...] |                       | 18.07                          | 1.3     |        |
| 5                    | Rev.' 9        | 35                                 | I                | Around the 22  | [first] | appearance in the | west   | in    | beginning of Gemini   | 51.893                         | 1.634   |        |
| 5                    | Rev.' 11       | 35                                 | III              | 3              | last    | appearance in the | west   | in    | Cancer                | 98.915                         | -2.532  |        |
| 5                    | Rev.' 12       | 35                                 | IV               | 21             | [last]  | appearance in the | east   | in    | Cancer                | 115.257                        | 1.563   |        |
| 5                    | Rev.' 12       | 35                                 | [VI]             | 12             | first   | appearance in the | west   |       | omitted               | 197.744                        | -2.366  |        |
| 5                    | Rev.' 12-13    | 35                                 | VII              | Around the 17? | [first] | appearance in the | [east] |       | [...]                 | 194.887                        | 2.011   |        |
| 5                    | Rev.' 15       | 35                                 | <X>              | 23             | last    | appearance in the | west   | in    | Aquarius              | 315.307                        | 3.393   |        |
| 5                    | Rev.' 15       | 35                                 | XI               | 11             | first   | appearance in the | east   | in    | Aquarius              | 302.334                        | 1.706   |        |
| 7                    | Obv. 14        | 45                                 | I                | 21             | last    | appearance in the | west   |       | [...]                 | from the 17th I did not see it | 30.653  | 1.281  |
| 7                    | Obv. 15        | 45                                 | III              | 3              | first   | appearance in the | east   |       | omitted               | 39.691                         | -2.224  |        |
| 7                    | Obv. 15        | 45                                 | III              | 13             | last    | appearance in the | east   |       | omitted               | 56.995                         | -0.31   |        |
| 7                    | Obv. 15        | 45                                 | IV               | 9              | first   | appearance in the | west   | in    | Cancer                | (ideal) first on 7             | 107.332 | 1.725  |
| 7                    | Obv. 15        | 45                                 | V                | 20             | last    | appearance in the | west   | in    | beginning of Virgo    | 155.085                        | -3.746  |        |
| 7                    | Obv. 16        | 45                                 | VI               | 14             | first   | appearance in the | east   | in    | end of Leo            | (ideal) first on 11            | 140.303 | -0.171 |
| 7                    | Obv. 16        | 45                                 | VII              | 6              | last    | appearance in the | east   | in    | Virgo                 | 167.425                        | 1.767   |        |
| 7                    | Obv. 16        | 45                                 | VIII             | 29             | first   | appearance in the | west   | in    | Sagittarius           | 249.738                        | -2.222  |        |
| 7                    | Obv. 16        | 45                                 | IX               | 14             | last    | appearance in the | west   | in    | Sagittarius           | 260.436                        | 0.341   |        |
| 7                    | Obv. 17        | 45                                 | IX               | Around the 26  | first   | appearance in the | east   | in    | Sagittarius           | 247.321                        | 3.334   |        |
| 7                    | Obv. 17        | 45                                 | XI               | 10             | last    | appearance in the | east   | in    | Capricorn             | 285.864                        | -1.75   |        |
| 7                    | Obv. 18        | 45                                 | XII <sub>2</sub> | Around the 10  | last    | appearance in the | west   | in    | Aries                 | 11.898                         | 2.897   |        |
| 9                    | 'Obv.' 13'     | 49                                 | II               | 27             | last    | appearance in the | west   | in    | Cancer                | 81.604                         | -2.964  |        |
| 9                    | 'Obv.' 13'     | 49                                 | III              | Around the 20  | first   | appearance in the | east   | in    | end of Gemini         | 73.633                         | -3.125  |        |
| 9                    | 'Obv.' 14'-15' | 49                                 | V                | 30             | [first] | appearance in the | west   |       | [...]                 | 182.279                        | -1.967  |        |
| 9                    | 'Obv.' 15'     | 49                                 | VI               | 10             | last    | appearance in the | west   | in    | Libra                 | 192.904                        | -2.961  |        |
| 9                    | 'Obv.' 15'     | 49                                 | VII              | Around the 7   | first   | appearance in the | east   | in    | Libra                 | 182.066                        | 1.203   |        |
| 9                    | 'Obv.' 16      | 49                                 | VIII             | 11             | last    | appearance in the | east   | in    | Scorpius              | 218.328                        | 0.254   |        |
| 9                    | 'Obv.' 16      | 49                                 | IX               | 22             | first   | appearance in the | west   | in    | Capricorn             | 283.275                        | -1.699  |        |
| 9                    | 'Obv. 17'      | 49                                 | XI               | 2              | first   | appearance in the | east   | in    | Capricorn             | 287.578                        | 2.238   |        |
| 9                    | 'Obv.' 18      | 49                                 | XII              | 10             | last    | appearance in the | east   |       | [...]                 | 327.438                        | -2.314  |        |

| ADART Vol. VI<br>No. |             | Observation date<br>(Seleucid Era) |                  |              |                      |                   |                      |    |                         | Tropical<br>Longitude | Latitude |
|----------------------|-------------|------------------------------------|------------------|--------------|----------------------|-------------------|----------------------|----|-------------------------|-----------------------|----------|
| 10                   | Obv.' 22    | 50                                 | I                | 7            | first                | appearance in the | west                 | in | beginning of Taurus     | 20.652                | 0.83     |
| 10                   | Obv.' 24-25 | 50                                 | II               | 13           | last                 | appearance in the | west                 | in | beginning of Gemini     | 62.857                | 0.041    |
| 10                   | Obv.' 25    | 50                                 | II               | 17           | last                 | appearance in the | west                 |    | [...]                   | 62.474                | -1.026   |
| 10                   | Obv.' 26    | 50                                 | IV               | Around the 7 | last                 | appearance in the | east                 |    | [...]                   | 88.622                | 1.039    |
| 13                   | Line 2'     | [51]                               | XII              | 1            | [first]              | appearance in the | [west]               |    | [...]                   | 358.267               | 0.752    |
| 12                   | 'Obv. 2'    | [51]                               | XII              | 29           | [last]               | appearance in the | west                 |    | [...]                   | 22.615                | 2.017    |
| 15                   | Obv. 17     | 60                                 | I                | 2            | [first]              | appearance in the | east                 |    | [...]                   | 350.147               | -2.68    |
| 15                   | Obv. 19     | 60                                 | IV               | 4            | [last]               | appearance in the | west                 | in | [Leo]                   | 123.268               | -3.44    |
| 15                   | Obv. 20     | 60                                 | VII              | 11           | first                | appearance in the | west                 |    | omitted                 | 217.54                | -2.439   |
| 15                   | Obv. 20     | 60                                 | VII              | 26           | [last <sup>2</sup> ] | appearance in the | [west <sup>2</sup> ] |    | [omitted <sup>2</sup> ] | 231.326               | -2.019   |
| 15                   | Obv. 21     | 60                                 | IX               | 27           | last                 | appearance in the | east                 | in | Sagittarius             | 263.294               | -1.411   |
| 16                   | 'Obv.' 20'  | 61                                 | I                | 9            | [last]               | appearance in the | east                 |    | [...]                   | 348.453               | -2.726   |
| 16                   | 'Obv.' 20'  | 61                                 | II               | 16           | first                | appearance in the | west                 | in | Gemini                  | 57.968                | 1.748    |
| 16                   | 'Obv.' 21'  | 61                                 | III              | 30           | [last]               | appearance in the | [west]               | in | Cancer                  | 104.579               | -3.439   |
| 16                   | 'Obv.' 21'  | 61                                 | IV               | 24           | [first]              | appearance in the | [east]               |    | [...]                   | 93.859                | -2.26    |
| 16                   | 'Obv.' 22'  | 61                                 | VII              | 5            | [first]              | appearance in the | [west]               |    | [omitted <sup>2</sup> ] | 201.785               | -2.342   |
| 20                   | Obv. 23     | 72                                 | I                | 2            | last                 | appearance in the | west                 | in | Aries                   | 18.216                | 2.784    |
| 20                   | Obv. 23     | 72                                 | II               | 14           | first                | appearance in the | east                 |    | omitted                 | 21.158                | -3.077   |
| 20                   | Obv. 23     | 72                                 | II               | 27           | last                 | appearance in the | east                 |    | omitted                 | 41.267                | -1.162   |
| 20                   | Obv. 24     | 72                                 | III              | 28           | first                | appearance in the | west                 | in | Cancer                  | 101.552               | 1.758    |
| 20                   | Obv. 25     | 72                                 | V                | 3            | last                 | appearance in the | west                 | in | Leo                     | 142.682               | -3.09    |
| 20                   | Obv. 25     | 72                                 | VI               | 1            | first                | appearance in the | east                 | in | Leo                     | 129.462               | -0.616   |
| 20                   | Obv. 25-26  | 72                                 | VI               | 24           | last                 | appearance in the | east                 | in | Virgo                   | 159.948               | 1.761    |
| 20                   | Obv. 26     | 72                                 | VIII             | 20           | first                | appearance in the | west                 | in | Sagittarius             | 243.699               | -2.262   |
| 20                   | Obv. 26     | 72                                 | VIII             | 29           | last                 | appearance in the | west                 | in | Sagittarius             | 249.959               | -0.962   |
| 20                   | Obv. 26     | 72                                 | IX               | 17           | first                | appearance in the | east                 | in | Sagittarius             | 234.537               | 3.175    |
| 20                   | Obv. 27     | 72                                 | X                | 27           | last                 | appearance in the | east                 | in | Capricorn               | 275.355               | -1.517   |
| 20                   | Obv. 27     | 72                                 | XII              | 1            | first                | appearance in the | west                 | in | Pisces                  | 336.609               | -0.079   |
| 20                   | Obv. 27     | 72                                 | XII <sub>2</sub> | 1            | last                 | appearance in the | west                 | in | Aries                   | 356.683               | 2.798    |
| 20                   | Obv. 27     | 72                                 | XII <sub>2</sub> | 23           | first                | appearance in the | east                 |    | omitted                 | 350.632               | -2.342   |

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|-----------------------------|------------------------------------|---------------------|-----------------|---------|-------------------|-------------------|----|--------------------------|---------------------|-----------------------|----------|
| 22 'Obv.' 13'               | 76                                 | I                   | 2               | first   | appearance in the | west              | in | Taurus                   |                     | 30.939                | 1.361    |
| 22 'Obv.' 15'               | 76                                 | V <sup>?</sup>      | 21              | last    | appearance in the | west              | in | Virgo                    |                     | 176.464               | -2.274   |
| 22 'Obv.' 16'               | 76                                 | VI                  | 24              | [first] | appearance in the | east              | in | Virgo                    |                     | 171.126               | 0.735    |
| 22 'Obv.' 17'               | 76                                 | [VII <sup>?</sup> ] | Around the 25   | [last]  | appearance in the | east              | in | Libra                    |                     | 203.895               | 0.835    |
| 22 'Obv.' 17'               | 76                                 | [IX]                | 10              | first   | appearance in the | west              | in | Capricorn <sup>?</sup>   |                     | 273.646               | -1.885   |
| 22 'Obv.' 18'               | 76                                 | XI                  | 24              | last    | appearance in the | east              | in | Aquarius                 |                     | 313.069               | -2.187   |
| 22 'Obv.' 18'               | 76                                 | XII                 | 26              | first   | appearance in the | west              | in | Aries                    |                     | 12.685                | 0.75     |
| 24 Line 5'                  | 78                                 | II                  | 17              | [last]  | appearance in the | east              |    | [...]                    |                     | 56.568                | -0.266   |
| 27 Obv. 17                  | [83]                               | I                   | 11              | first   | appearance in the | west <sup>?</sup> | in | Taurus <sup>?</sup>      |                     | 22.335                | 1.043    |
| 27 Obv. 19                  | [83]                               | III <sup>?</sup>    | 26 <sup>?</sup> | [first] | appearance in the | east <sup>?</sup> |    | [...]                    |                     | 63.378                | -1.68    |
| 26 'Obv.' 3'                | [83]                               | V                   | 11              | first   | appearance in the | west              | in | end of Leo               |                     | 143.763               | 0.486    |
| 27 Obv. 21                  | [83]                               | VII                 | 7               | first   | appearance in the | east <sup>?</sup> | in | Virgo                    |                     | 163.94                | 0.944    |
| 26 'Obv.' 5'                | [83]                               | VIII                | Around the 4    | last    | appearance in the | east              | in | Libra                    |                     | 195.001               | 1.157    |
| 26 'Obv.' 6'                | [83]                               | X                   | 10              | last    | appearance in the | west              | in | Capricorn <sup>?</sup>   |                     | 284.084               | 1.775    |
| 26 'Obv.' 6'                | [83]                               | [X]                 | Around the 24   | first   | appearance in the | east              | in | Capricorn                |                     | 270.136               | 3.437    |
| 26 'Obv.' 7'                | [83]                               | [XII]               | Around the 7    | [last]  | appearance in the | east              |    | [...]                    |                     | 310.328               | -2.158   |
| 27 Obv. 25                  | [83]                               | XII <sub>2</sub>    | 6               | [first] | appearance in the | [west]            | in | [Aries]                  |                     | 6.122                 | 0.556    |
| 28 'Obv.' 2'                | [85]                               | II                  | 13              | ...     | appearance in the | east              |    | [...]                    |                     | 26.644                | -2.833   |
| 28 'Obv.' 4'                | [85]                               | VI                  | 18              | [last]  | appearance in the | east              | in | Virgo                    |                     | 159.28                | 1.835    |
| 28 'Obv.' 4'-5'             | [85]                               | VIII                | 17              | [last]  | appearance in the | [west]            | in | Sagittarius              |                     | 247.518               | -2.113   |
| 28 'Obv.' 5'                | [85]                               | IX                  | 12              | first   | appearance in the | east              | in | Sagittarius <sup>?</sup> |                     | 237.597               | 3.208    |
| 35 Obv. 12                  | 94                                 | I                   | 15              | last    | appearance in the | east              | in | Aries                    |                     | 350.782               | -2.641   |
| 35 Obv. 12-13               | 94                                 | II                  | 19              | [first] | appearance in the | [west]            |    | [...]                    | (ideal) first on 17 | 57.586                | 1.776    |
| 35 Obv. 14                  | 94                                 | IV                  | 2               | [last]  | appearance in the | [west]            | in | [Cancer]                 |                     | 102.472               | -3.535   |
| 35 Obv. 15                  | 94                                 | IV                  | 26              | first   | appearance in the | east              | in | Cancer                   | (ideal) first on 25 | 92.482                | -2.176   |
| 35 Obv. 16                  | 94                                 | VI <sub>2</sub>     | 9               | first   | appearance in the | west              |    | omitted                  |                     | 202.342               | -2.468   |
| 35 Obv. 16                  | 94                                 | VI <sub>2</sub>     | 23              | [last]  | appearance in the | west              |    | omitted                  |                     | 213.943               | -2.704   |
| 35 Obv. 17                  | 94                                 | VII                 | 12              | first   | appearance in the | east              | in | Libra                    | (ideal) first on 10 | 198.461               | 2.134    |
| 35 Obv. 18                  | 94                                 | VIII                | 21              | last    | appearance in the | east              | in | Sagittarius              |                     | 241.111               | -0.657   |
| 35 Obv. 19                  | 94                                 | IX                  | 27              | first   | appearance in the | west              | in | Aquarius                 |                     | 299.469               | -1.33    |

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|----------------------|----------------|------------------------------------|-------------------|-----------------|---------|-------------------|--------|----|--------------------|-------------------------------------|----------|--------|
| 35                   | Obv. 20        | 94                                 | X                 | Around the 18   | last    | appearance in the | west   | in | Aquarius           | 319.628                             | 3.27     |        |
| 35                   | Obv. 20        | 94                                 | XI                | 7               | first   | appearance in the | east   | in | Aquarius           | 306.4                               | 1.843    |        |
| 35                   | Obv. 21        | 94                                 | XII               | Around the 10   | [last]  | appearance in the | east   | in | Pisces             | 336.793                             | -2.489   |        |
| 37                   | 'Obv. 5'       | 96                                 | I                 | 7               | first   | appearance in the | west   | in | Taurus             | 23.351                              | 0.98     |        |
| 37                   | 'Obv. 7'       | 96                                 | [II]              | 13              | last    | appearance in the | west   | in | Gemini             | 63.998                              | -0.192   |        |
| 37                   | 'Obv. 7'       | 96                                 | III               | 21              | [first] | appearance in the | east   | in | Gemini             | 63.73                               | -2       |        |
| 37                   | 'Obv. 8'       | 96                                 | IV                | 7               | last    | appearance in the | east   | in | Gemini             | 89.236                              | 1.024    |        |
| 37                   | 'Obv. 8'       | 96                                 | V                 | 11              | first   | appearance in the | west   | in | end of Leo         | 151.018                             | 0.028    |        |
| 37                   | 'Obv. 9'       | 96                                 | VI                | Around the 6    | last    | appearance in the | west   | in | end of Virgo       | 179.283                             | -3.095   |        |
| 37                   | 'Obv. 9'       | 96                                 | VII               | 2               | [first] | appearance in the | [east] | in | [Virgo]            | 166.907                             | 0.596    |        |
| 37                   | 'Obv. 10'      | 96                                 | IX                | 18              | [first] | appearance in the | [west] | in | [Capricorn]        | 273.341                             | -1.787   |        |
| 37                   | 'Obv. 11'      | 96                                 | [X <sup>2</sup> ] | 21 <sup>2</sup> | first   | appearance in the | east   | in | Capricorn          | 272.273                             | 3.262    |        |
| 39                   | Obv. 25        | 98                                 | XII               | 22              | last    | appearance in the | west   |    | [...]              | 3.443                               | 2.706    |        |
| 44                   | 'Obv.' 16'     | [109]                              | I                 | 6               | [first] | appearance in the | west   | in | Taurus             | 32.508                              | 1.547    |        |
| 46                   | Obv. 17        | [114]                              | I                 | 28              | [first] | appearance in the | west   |    | [...]              | 58.109                              | 1.924    |        |
| 46                   | Obv. 19        | [114]                              | IV                | 10              | first   | appearance in the | east   | in | Cancer             | 93.714                              | -0.66    |        |
| 50                   | 'Obv. 5'       | [122]                              | I                 | 2               | first   | appearance in the | west   | in | Taurus             | 31.57                               | 1.342    |        |
| 50                   | 'Obv. 8'       | [122]                              | II                | 8               | last    | appearance in the | west   | in | Gemini             | 70.266                              | -1.063   |        |
| 48                   | 'Obv. 7'       | [122]                              | [X]               | 15              | first   | appearance in the | east   | in | Capricorn          | 277.29                              | 2.972    |        |
| 48                   | 'Obv. 8'       | [122]                              | XI                | Around the 17   | last    | appearance in the | east   | in | Aquarius           | 304.461                             | -1.889   |        |
| 48                   | 'Obv. 9'       | [123]                              | I                 | [...]           | first   | appearance in the | [west] | in | end of Aries       | (ideal) first on 26 of XII in Aries | 17.379   | 1.085  |
| 53                   | 'Obv.' 14'     | 125                                | I                 | 25              | first   | appearance in the | east   |    | omitted            | 17.765                              | -2.896   |        |
| 53                   | 'Obv.' 14'     | 125                                | II                | 9               | [last]  | appearance in the | east   |    | [omitted]          | 39.225                              | -0.999   |        |
| 53                   | 'Obv.' 15'     | 125                                | [III]             | [...]           | first   | appearance in the | west   | in | Cancer             | (ideal) first on 2                  | 84.717   | 1.88   |
| 53                   | 'Obv.' 16'     | 125                                | IV                | 14              | last    | appearance in the | west   | in | Leo                | from the 12 I did not see           | 137.254  | -3.386 |
| 53                   | 'Obv.' 16'-17' | 125                                | V                 | 14              | [first] | appearance in the | east   | in | Leo                | (ideal) first on 9                  | 124.982  | -0.096 |
| 53                   | 'Obv.' 17'     | 125                                | VI                | Around the 2    | last    | appearance in the | east   | in | beginning of Virgo | 151.038                             | 1.867    |        |
| 53                   | 'Obv.' 17'-18' | 125                                | VIII              | 1               | first   | appearance in the | [west] | in | Scorpius           | (ideal) first on 28 of VII          | 239.274  | -2.349 |
| 53                   | 'Obv.' 18'     | 125                                | VIII              | 15              | last    | appearance in the | west   | in | Sagittarius        | 241.651                             | 0.442    |        |
| 53                   | 'Obv.' 19'     | 125                                | VIII              | [...]           | first   | appearance in the | east   | in | Scorpius           | (ideal) first on 24                 | 230.274  | 2.889  |

| ADART Vol. VI |                | Observation date |                    |                 |         |                   |        |    | Tropical              |                         | Latitude |        |
|---------------|----------------|------------------|--------------------|-----------------|---------|-------------------|--------|----|-----------------------|-------------------------|----------|--------|
| No.           |                | (Seleucid Era)   |                    |                 |         |                   |        |    | Longitude             |                         |          |        |
| 53            | 'Obv.' 20'     | 125              | X                  | 8               | last    | appearance in the | east   | in | Capricorn             |                         | 271.853  | -1.478 |
| 53            | 'Obv.' 20'-21' | 125              | XI                 | 14              | [first] | appearance in the | west   | in | Pisces                | (ideal) first on 12     | 336.188  | 0.279  |
| 53            | 'Obv.' 21'     | 125              | XII                | Around the 1    | last    | appearance in the | west   | in | end of Pisces         |                         | 353.137  | 3.408  |
| 57            | Obv.' 25       | [135]            | III                | 9               | [first] | appearance in the | east   | in | Gemini                |                         | 70.191   | -2.081 |
| 57            | Obv.' 26       | [135]            | V                  | Around the 7    | first   | appearance in the | west   | in | Virgo                 |                         | 167.508  | -1.015 |
| 57            | Obv.' 27       | [135]            | VI                 | 22              | [first] | appearance in the | east   | in | end of Virgo          |                         | 174.709  | 0.897  |
| 57            | Obv.' 28       | [135]            | IX                 | 27              | [last]  | appearance in the | west   |    | [...]                 |                         | 293.519  | 2.736  |
| 57            | Obv.' 29       | [135]            | [X]                | 12              | [first] | appearance in the | east   | in | Aquarius              |                         | 279.988  | 2.896  |
| 57            | Obv.' 30       | [135]            | [XI <sup>?</sup> ] | 24              | last    | appearance in the | east   | in | beginning of Pisces   |                         | 324.967  | -2.241 |
| 59            | Line 4'        | 137              | [II]               | Around the 22   | [first] | appearance in the | [east] |    | [omitted]             |                         | 31.573   | -3.389 |
| 61            | 'Obv. 21'-22'  | [139]            | VIII               | [...]           | [first] | appearance in the | east   | in | Scorpius              | (ideal) first on 13     | 217.629  | 2.246  |
| 61            | 'Obv 23'       | [139]            | IX                 | 29              | last    | appearance in the | east   | in | Sagittarius           | from 26 not seen        | 261.991  | -1.338 |
| 61            | 'Obv. 24'      | [139]            | XI <sup>?</sup>    | Around the 27   | last    | appearance in the | west   | in | Pisces                |                         | 335.804  | 3.706  |
| 61            | 'Obv. 24'-25'  | [139]            | XII                | 20              | first   | appearance in the | [east] |    | [...]                 | (ideal) first on 17     | 327.003  | -0.81  |
| 62            | Obv.' 14       | [140]            | [I]                | [1]6            | last    | appearance in the | east   | in | Aries                 |                         | 354.651  | -2.562 |
| 62            | Obv.' 14       | [140]            | II                 | 17 <sup>?</sup> | first   | appearance in the | west   | in | Gemini                |                         | 54.121   | 1.56   |
| 62            | Obv.' 16       | [140]            | IV                 | [...]           | last    | appearance in the | [west] | in | Cancer                | from 28 of III not seen | 104.129  | -2.591 |
| 62            | Obv.' 16       | [140]            | IV                 | 26              | [first] | appearance in the | east   |    | [...]                 |                         | 93.449   | -2.215 |
| 62            | Obv.' 17       | [140]            | V <sup>?</sup>     | 17              | last    | appearance in the | east   | in | beginning of Leo      |                         | 121.432  | 1.672  |
| 62            | Obv.' 17-18    | [140]            | VIII <sup>?</sup>  | 9               | first   | appearance in the | [east] | in | Libra                 | (ideal) first on 8      | 201.833  | 1.461  |
| 62            | Obv.' 20       | [140]            | XI                 | 18              | [last]  | appearance in the | west   | in | end of Capricorn      |                         | 320.319  | 3.415  |
| 68            | 'Obv.' 13'     | 146              | II                 | 9               | first   | appearance in the | west   | in | Gemini                |                         | 77.216   | 2.033  |
| 68            | 'Obv.' 15'     | 146              | [IV <sup>?</sup> ] | [...]           | first   | appearance in the | [east] |    | [...]                 | (ideal) first on 11     | 102.839  | -2.105 |
| 68            | 'Obv.' 16'     | 146              | VII                | Around the 11   | last    | appearance in the | west   |    | omitted               |                         | 224.333  | -1.941 |
| 68            | 'Obv' 16'      | 146              | VII                | 29              | [first] | appearance in the | east   | in | beginning of Scorpius | (ideal) first on 27     | 208.202  | 2.661  |
| 68            | 'Obv.' 17'-18' | 146              | [IX]               | Around the 5    | last    | appearance in the | east   | in | Sagittarius           |                         | 246.998  | -0.638 |
| 68            | 'Obv.' 18'     | 146              | X                  | 14 <sup>?</sup> | first   | appearance in the | west   | in | Aquarius              |                         | 313.032  | -0.761 |
| 68            | 'Obv.' 19'     | 146              | [XI <sup>?</sup> ] | 27              | first   | appearance in the | east   | in | beginning of Pisces   |                         | 318.17   | 0.314  |
| 68            | 'Obv.' 19'     | 146              | XII                | 23              | [last]  | appearance in the | east   | in | end of Pisces         |                         | 343.585  | -2.613 |
| 69            | Obv. 20        | 148              | I                  | 26              | first   | appearance in the | [west] | in | [Tau]rus              |                         | 41.65    | 1.769  |

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|----------------------|------------|------------------------------------|---------------------|-----------------|---------|-------------------|--------|----|---------------------|--|---------|----------|
| 69                   | Obv. 23-24 | 148                                | [III <sup>2</sup> ] | [...]           | [last]  | appearance in the | west   | in | Gemini              | from the 1 not seen                            | 76.614  | -1.388   |
| 69                   | Obv. 24    | 148                                | IV                  | 7               | first   | appearance in the | east   | in | Gemini              | [(ideal) first] on 4                           | 75.391  | -1.471   |
| 69                   | Obv. 25    | 148                                | IV <sup>2</sup>     | 23              | last    | appearance in the | east   | in | Cancer              |  | 103.375 | 1.466    |
| 69                   | Obv. 25    | 148                                | VI                  | 4               | first   | appearance in the | west   | in | Virgo               |  | 171.489 | -1.224   |
| 69                   | Obv. 25-26 | 148                                | VI                  | [...]           | [last]  | appearance in the | west   | in | beginning of Libra  | from the 16 not seen                           | 185.648 | -2.686   |
| 69                   | Obv. 26    | 148                                | VII                 | 18              | first   | appearance in the | east   | in | beginning of Libra  | (ideal) first on 14                            | 176.686 | 1.542    |
| 69                   | Obv. 28    | 148                                | X                   | 5               | first   | appearance in the | west   | in | Capricorn           | (ideal) first on 4                             | 284.772 | -1.441   |
| 69                   | Obv. 28-29 | 148                                | X                   | [...]           | last    | appearance in the | west   | in | Aquarius            | from the 20 not seen                           | 297.575 | 2.061    |
| 69                   | Obv. 29    | 148                                | XI                  | 10              | first   | appearance in the | east   | in | Capricorn           | (ideal) first on 8                             | 282.544 | 2.616    |
| 69                   | Obv. 31-32 | 148                                | XII                 | 17              | last    | appearance in the | east   | in | Pisces              | from the 14 in the end of<br>Aquarius not seen | 320.99  | -2.274   |
| 69                   | Obv. 32-33 | 148                                | XII <sub>2</sub>    | 23              | first   | appearance in the | [west] | in | Taurus              | (ideal) first on 20 in the end of<br>Aries     | 29.269  | 1.749    |
| 71                   | 'Obv. 15'  | [152]                              | I                   | Around the 2    | first   | appearance in the | east   |    | omitted             |  | 354.459 | -2.915   |
| 71                   | 'Obv. 15'  | [152]                              | I                   | Around the 20   | [last]  | appearance in the | east   |    | [omitted]           |  | 18.338  | -2.145   |
| 71                   | 'Obv. 17'  | [152]                              | IV                  | 2               | last    | appearance in the | [west] |    | [...]               |  | 125.431 | -3.386   |
| 71                   | 'Obv. 18'  | [152]                              | [IV]                | 27              | first   | appearance in the | east   | in | end of Cancer       |  | 112.753 | -1.368   |
| 71                   | 'Obv. 19'  | [152]                              | [V <sup>2</sup> ]   | Around the 17   | last    | appearance in the | east   | in | Leo                 |  | 136.13  | 1.809    |
| 71                   | 'Obv. 19'  | [152]                              | VII                 | Around the 11   | [first] | appearance in the | west   |    | [omitted]           |  | 220.321 | -2.473   |
| 71                   | 'Obv. 20'  | [152]                              | VIII                | 14              | first   | appearance in the | east   | in | Scorpius            |  | 217.861 | 2.781    |
| 71                   | 'Obv. 22'  | [152]                              | XI                  | 1               | first   | appearance in the | west   | in | beginning of Pisces |  | 324.273 | -0.239   |
| 71                   | 'Obv. 23'  | [152]                              | XII                 | 21 <sup>2</sup> | first   | appearance in the | east   | in | Pisces              |  | 333.011 | -1.813   |
| 73                   | Obv. 37'   | 155                                | V                   | Around the 5    | first   | appearance in the | west   | in | Virgo <sup>2</sup>  |  | 151.36  | 0.205    |
| 73                   | Obv. 37'   | 155                                | V                   | Around the 27   | [last]  | appearance in the | [west] |    | [...]               |  | 179.499 | -2.676   |
| 73                   | Obv. 38'   | 155                                | VI                  | 28              | [first] | appearance in the | east   | in | Virgo               |  | 170.192 | 1.022    |
| 73                   | Obv. 40'   | 155                                | [IX]                | 9 <sup>2</sup>  | [first] | appearance in the | west   | in | [Capricorn]         |  | 268.996 | -2.05    |
| 73                   | Rev. 1-2   | 155                                | [X]                 | [...]           | [first] | appearance in the | east   | in | Capricorn           | (ideal) first on 14                            | 277.919 | 3.609    |
| 73                   | Rev. 3     | 155                                | XI                  | 28              | last    | appearance in the | east   | in | Aquarius            | from the 26 not seen                           | 314.917 | -2.204   |
| 73                   | Rev. 4     | 156                                | I                   | 1               | first   | appearance in the | west   | in | Aries               | (ideal) first on 30 of XII                     | 16.929  | 1.129    |
| 73                   | Rev. 6     | 156                                | [II]                | Around the 7    | last    | appearance in the | west   | in | end of Taurus       |  | 46.694  | -0.689   |
| 73                   | Rev. 6     | 156                                | III                 | 13              | first   | appearance in the | east   | in | Gemini              |  | 53.745  | -1.941   |

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|----------------------|-------------|------------------------------------|--------------------|----------------------------|---------|-------------------|--------|----|----------------------|-----------------------------------|----------|--------|
| 73                   | Rev. 7      | 156                                | III                | Around the 25              | last    | appearance in the | east   | in | Gemini               |                                   | 74.869   | 0.477  |
| 73                   | Rev. 7      | 156                                | IV                 | 24                         | [first] | appearance in the | west   | in | Leo                  |                                   | 128.964  | 1.131  |
| 73                   | Rev. 8      | 156                                | V                  | Around the 26              | [last]  | appearance in the | west   | in | Virgo                |                                   | 167.889  | -3.24  |
| 74                   | Obv.' 21-22 | 156                                | VI                 | [...]                      | first   | appearance in the | [east] | in | Virgo                | (ideal) first on 23 <sup>2</sup>  | 154.323  | 0.184  |
| 74                   | Obv.' 22    | 156                                | VII                | Around the 17              | last    | appearance in the | east   | in | Libra                |                                   | 181.886  | 1.57   |
| 73                   | Rev. 10-11  | 156                                | IX                 | 11                         | [first] | appearance in the | [west] | in | [end of Sagittarius] | (ideal) first on 9 in Sagittarius | 264.388  | -1.91  |
| 74                   | Obv.' 24-25 | 156                                | IX <sup>2</sup>    | Around the 24 <sup>2</sup> | last    | appearance in the | west   | in | Capricorn            |                                   | 274.693  | 0.683  |
| 73                   | Rev. 12     | 156                                | X                  | Around the 8               | first   | appearance in the | east   | in | Sagittarius          |                                   | 260.91   | 3.533  |
| 73                   | Rev. 13     | 156                                | XI                 | Around the 22              | last    | appearance in the | east   | in | Aquarius             |                                   | 300.172  | -2.001 |
| 73                   | Rev. 13     | 156                                | XII                | 28                         | first]  | appearance in the | [west] | in | [Aries]              |                                   | 6.377    | 1.208  |
| 73                   | Rev. 15     | 156                                | XII <sub>2</sub>   | Around the 26              | last    | appearance in the | west   | in | beginning of Taurus  |                                   | 27.504   | 1.445  |
| 75                   | 'Obv.' 16'  | [159]                              | III                | 1                          | [first] | appearance in the | west   | in | Gemini               |                                   | 70.672   | 1.888  |
| 77                   | Obv. 10     | [161]                              | I                  | 21                         | first   | appearance in the | west   | in | Taurus               | (ideal) first on 19               | 42.743   | 1.717  |
| 77                   | Obv. 14     | [161]                              | III                | 2                          | last    | appearance in the | west   | in | end of Gemini        | from 28 of II not seen            | 78.516   | -2.866 |
| 77                   | Obv. 14     | [161]                              | IV                 | 1                          | first   | appearance in the | east   | in | Gemini               | (ideal) first on 27 of III        | 74.959   | -2.058 |
| 77                   | Obv. 16     | [161]                              | IV <sup>2</sup>    | Around the 16              | [last]  | appearance in the | [east] |    | [...]                |                                   | 98.373   | 1.093  |
| 77                   | Obv. 16     | [161]                              | [V <sup>2</sup> ]  | Around the 25              | [first] | appearance in the | west   |    | omitted              |                                   | 167.182  | -0.65  |
| 77                   | Obv. 17     | [161]                              | VII                | 14                         | [first] | appearance in the | east   |    | [...]                | (ideal) first on 13               | 179.336  | 1.492  |
| 77                   | Obv. 18     | [161]                              | X                  | 1                          | [first] | appearance in the | west   | in | Capricorn            | (ideal) first on 28 [of IX]       | 286.096  | -1.471 |
| 77                   | Obv. 19     | [161]                              | XI                 | 4                          | first   | appearance in the | east   | in | Capricorn            |                                   | 285.705  | 2.922  |
| 81                   | 'Obv.' 9'   | [176]                              | I                  | Around the 11              | last    | appearance in the | west   | in | Taurus               |                                   | 42.155   | 0.266  |
| 81                   | 'Obv.' 9'   | [176]                              | II                 | 23                         | first   | appearance in the | east   | in | end of Taurus        |                                   | 53.068   | -1.591 |
| 81                   | 'Obv.' 10'  | [176]                              | [II <sup>2</sup> ] | 29                         | last    | appearance in the | east   | in | Gemini               |                                   | 63.522   | -0.366 |
| 81                   | 'Obv.' 10'  | [176]                              | IV                 | 2                          | first   | appearance in the | west   | in | Leo                  | (ideal) first on 1                | 125.783  | 1.189  |
| 81                   | 'Obv.' 11'  | [176]                              | VI                 | 1                          | first   | appearance in the | east   | in | Virgo                |                                   | 150.155  | 0.337  |
| 81                   | 'Obv.' 12'  | [176]                              | VIII               | 19                         | first   | appearance in the | west   | in | Sagittarius          | (ideal) first on 18               | 263.453  | -1.793 |
| 81                   | 'Obv.' 14'  | [176]                              | XII                | 5 <sup>2</sup>             | first   | appearance in the | west   | in | Aries                |                                   | 2.788    | 1.141  |
| 82                   | Obv.' 17    | 179                                | II                 | 8                          | first   | appearance in the | west   | in | Gemini               | (ideal) first on 6                | 69.245   | 1.939  |
| 82                   | Obv.' 19    | 179                                | III                | [...]                      | last    | appearance in the | west   | in | end of Cancer        | from the 20 not seen              | 112.866  | -3.556 |
| 82                   | Obv.' 19    | 179                                | IV                 | 16                         | [first] | appearance in the | east   | in | Cancer               |                                   | 101.792  | -1.732 |

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|-----------------------------|---------------|------------------------------------|------------------|-----------------|---------|-------------------|--------|----|---------------------|------------------------|----------|--------|
| 82                          | Obv.' 20      | 179                                | V                | Around the 5    | last    | appearance in the | east   | in | Leo                 | 128.376                | 1.746    |        |
| 82                          | Obv.' 20      | 179                                | VII              | 2               | first   | appearance in the | west   |    | omitted             | 215.613                | -2.716   |        |
| 82                          | Obv.' 20-21   | 179                                | VII              | 14 <sup>2</sup> | last    | appearance in the | west   |    | omitted             | 222.862                | -2.104   |        |
| 86                          | Obv. 20       | 190                                | II               | Around the 6    | first   | appearance in the | <east> |    | omitted             | 39.897                 | -1.906   |        |
| 86                          | Obv. 20-21    | 190                                | II               | Around the 20   | last    | appearance in the | east   |    | omitted             | 66.845                 | 0.684    |        |
| 86                          | Obv. 21       | 190                                | III              | 19              | first   | appearance in the | west   | in | Cancer              | (ideal) first on 17    | 108.579  | 1.664  |
| 86                          | Obv. 22       | 190                                | IV               | Around the 23   | last    | appearance in the | west   | in | Leo                 |                        | 150.102  | -3.151 |
| 86                          | Obv. 22       | 190                                | V                | 24              | first   | appearance in the | east   | in | Leo                 | (ideal) first on 21    | 136.906  | -0.108 |
| 86                          | Obv. 23       | 190                                | VI               | 12              | <last>  | appearance in the | east   | in | Virgo               | from the 12 not seen   | 161.705  | 1.87   |
| 86                          | Obv. 23       | 190                                | VIII             | Around the 8    | first   | appearance in the | west   | in | Sagittarius         |                        | 247.118  | -2.295 |
| 86                          | Obv. 23-24    | 190                                | VIII             | Around the 23   | last    | appearance in the | west   | in | Sagittarius         |                        | 256.636  | 0.202  |
| 86                          | Obv. 24       | 190                                | IX               | Around the 7    | first   | appearance in the | east   | in | Sagittarius         |                        | 242.411  | 3.268  |
| 86                          | Obv. 24       | 190                                | X                | Around the 13   | last    | appearance in the | east   | in | Capricorn           |                        | 274.349  | -1.208 |
| 86                          | Obv. 25       | 190                                | XI               | 24              | first   | appearance in the | west   | in | Pisces              | (ideal) first on 23    | 345.872  | 0.331  |
| 86                          | Obv. 26       | 190                                | XII              | Around the 17   | last    | appearance in the | west   | in | Aries               |                        | 7.449    | 3.199  |
| 88                          | 'Obv. 8'      | [199]                              | III              | 29              | last    | appearance in the | west   |    | [...]               |                        | 107.162  | -3.962 |
| 88                          | 'Obv. 10'-11' | [199]                              | VII              | Around the 18   | [last]  | appearance in the | west   |    | omitted             |                        | 218.731  | -2.512 |
| 88                          | 'Obv. 11'     | [199]                              | VIII             | 8               | [first] | appearance in the | east   |    | [...]               |                        | 202.81   | 2.375  |
| 88                          | 'Obv. 13'     | [199]                              | X                | 22 <sup>2</sup> | first   | appearance in the | west   | in | Aquarius            | (ideal) first on 21    | 303.747  | -1.264 |
| 88                          | 'Obv. 14'     | [199]                              | [XI]             | [...]           | last    | appearance in the | west   | in | beginning of Pisces | from the 11 not seen   | 325.028  | 2.902  |
| 88                          | 'Obv. 14'     | [199]                              | XII              | Around the 5    | first   | appearance in the | east   | in | Aquarius            |                        | 311.369  | 1.036  |
| 88                          | 'Obv. 15'     | [199]                              | XII <sup>2</sup> | Around the 28   | last    | appearance in the | east   | in | Pisces              |                        | 330.735  | -2.414 |
| 92                          | Obv. 11       | [201]                              | I                | 4               | first   | appearance in the |        |    | [...]               | (ideal) first on 3     | 31.786   | 1.362  |
| 92                          | Obv. 13       | [201]                              | II               | Around the 11   | last    | appearance in the | west   | in | Gemini              |                        | 69.25    | -1.116 |
| 94                          | Obv.' 2       | 209                                | I <sup>2</sup>   | [...]           | [last]  | appearance in the | west   | in | Taurus              | from the 10 [not seen] | 40.903   | 1.223  |
| 94                          | Obv.' 3       | 209                                | [III]            | [...]           | first   | appearance in the | [east] |    | [...]               | (ideal) first on 20    | 43.814   | -2.651 |

#### Appendix K4: Mercury phenomena from the Almanacs and Normal Star Almanacs

| Text | Prediction date<br>(Seleucid Era) | Tropical<br>longitude | Latitude |
|------|-----------------------------------|-----------------------|----------|
|------|-----------------------------------|-----------------------|----------|



| Text          |            | Prediction date<br>(Seleucid Era) |                     |                           |   | Tropical<br>longitude | Latitude |
|---------------|------------|-----------------------------------|---------------------|---------------------------|---|-----------------------|----------|
| LBAT 998      | Rev. 2'    | 55                                | XI                  | 4                         | Mercury's last appearance in the west in Aquarius           | 308.082               | 3.766    |
| LBAT 998      | Rev. 4'    | 55                                | XI                  | 16                        | Mercury's first appearance in the east in Aquarius          | 298.414               | 2.657    |
| MMA 86.11.369 | Obv. 4     | 70                                | XII                 | 12                        | Mercury's first appearance in the west in Aries             | 7.086                 | 0.81     |
| MMA 86.11.369 | Obv. 12    | 70                                | I                   | 23                        | Mercury's last appearance in the west in the Chariot        | 57.181                | -0.649   |
| MMA 86.11.369 | Obv. 16    | 70                                | II                  | 25                        | Mercury's first appearance in the east in Gemini            | 54.64                 | -2.835   |
| MMA 86.11.369 | Rev. 14'   | 70                                | III                 | 12                        | Mercury's last appearance in the east in Cancer             | 79.139                | 0.487    |
| BM 40101+     | Obv. 9     | 92                                | IV                  | 12                        | Mercury's last appearance in the west in Leo                | 139.128               | -3.626   |
| BM 40101+     | Rev. 5     | 92                                | X                   | 7                         | Mercury's last appearance in the east in Capricorn.         | 275.442               | -1.616   |
| LBAT 1008     | Rev. 14-15 | 96                                | X                   | 8                         | Mercury's last appearance in the west in Capricorn          | 285.268               | 2.541    |
| LBAT 1010     | Rev. 7     | 104                               | IX                  | 22                        | Mercury's first appearance in the east in Sagittarius [...] | 250.996               | 3.394    |
| BM 40625      | Obv. 2     | 105                               | I                   | 18                        | Mercury's first appearance in the east omitted              | 20.249                | -3.022   |
| BM 40625      | Obv. 4     | 105                               | II                  | 1                         | Mercury's last appearance in the east omitted               | 38.927                | -1.298   |
| BM 40625      | Obv. 12    | 105                               | IV                  | 12                        | Mercury's last appearance in the west in 'x'                | 141.702               | -4.064   |
| BM 40625      | Rev. 2     | 105                               | VIII                | 5                         | Mercury's last appearance in the west in Sagittarius.       | 247.61                | -0.069   |
| BM 41022+     | Obv. 6     | 106                               | IV                  | 27                        | Mercury's first appearance in the east in Cancer            | 111.346               | -1.933   |
| LBAT 1016-18  | Rev. 5     | 107                               | XI                  | 18                        | Mercury's last appearance in the west in Pisces.            | 244.773               | -0.799   |
| LBAT 1019     | Rev. 5     | 108                               | [IX]                | 20                        | Mercury's first appearance in the west in Capricorn         | 358.718               | -1.115   |
| LBAT 1020     | Obv. 4     | 111                               | [II <sup>?</sup> ]  | 7                         | Mercury's first appearance in the east omitted              | 33.894                | -2.59    |
| LBAT 1020     | Obv. 6     | 111                               | [II <sup>?</sup> ]  | 26                        | Mercury's last appearance in the east, omitted.             | 68.721                | 0.826    |
| LBAT 1020     | Obv. 8     | 111                               | [III <sup>?</sup> ] | 13                        | Mercury's first appearance in the west in Cancer.           | 102.897               | 1.803    |
| LBAT 1020     | Obv. 10-11 | 111                               | [IV <sup>?</sup> ]  | 24                        | Mercury's last appearance in the west [...]                 | 151.727               | -3.67    |
| LBAT 1020     | Obv. 12    | 111                               | [V <sup>?</sup> ]   | 9 (or [1]9 <sup>?</sup> ) | Mercury's first appearance in the east in Leo.              | 137.216               | -0.335   |
| LBAT 1020     | Obv. 13    | 111                               | VI                  | 12                        | Mercury's last appearance in the east in Virgo.             | 166.592               | 1.724    |
| LBAT 1020     | Rev. 3     | 111                               | XI                  | 20                        | Mercury's first appearance in the west in Pisces.           | 343.818               | 0.112    |
| LBAT 1021     | Rev. 6     | 116                               | IX                  | 27                        | Mercury's first appearance in the east in Capricorn         | 268.162               | 3.371    |
| LBAT 1022     | Rev. 5     | 120                               | [XII <sup>?</sup> ] | 30                        | Mercury's last appearance in the east in Pisces             | 337.855               | -2.554   |
| LBAT 1123     | Obv. 1     | 129                               | I                   | 12                        | Mercury's first appearance in the west in Taurus            | 25.009                | 1.188    |
| LBAT 1123     | Obv. 5     | 129                               | II                  | 21                        | Mercury's last appearance in the west in Gemini             | 60.676                | -1.639   |
| LBAT 1123     | Obv. 6     | 129                               | III                 | 24                        | Mercury's first appearance in the east in Gemini            | 62.85                 | -1.932   |
| LBAT 1123     | Obv. 7     | 129                               | IV                  | 9                         | Mercury's last appearance in the east in the end of Gemini  | 86.828                | 0.907    |

| Text        |          | Prediction date<br>(Seleucid Era) |                  |                   |   | Tropical<br>longitude | Latitude |
|-------------|----------|-----------------------------------|------------------|-------------------|---|-----------------------|----------|
| LBAT 1123   | Obv. 9   | 129                               | V                | 11                | Mercury's first appearance in the west in the end of Leo                | 146.006               | 0.375    |
| LBAT 1123   | Rev. 4   | 129                               | XII <sub>2</sub> | 7                 | Mercury's first appearance in the west in Aries                         | 8.781                 | 0.72     |
| LBAT 1029   | Obv. 9   | 146                               | V                | 2                 | Mercury's last appearance in the east in Leo                            | 130.662               | 1.782    |
| LBAT 1030   | Rev. 4   | 146                               | VIII             | 6                 | Mercury's first (?) appearance in the east in Sagittarius               | 210.451               | 2.602    |
| LBAT 1034-5 | Obv. 6   | 157                               | VIII             | 10                | Mercury's first appearance in the west in Sagittarius                   | 254.834               | -1.827   |
| LBAT 1034-5 | Obv. 11  | 157                               | IX               | 2                 | Mercury's first appearance in the east in Sagittarius                   | 245.26                | 3.249    |
| LBAT 1127   | Obv. 7   | 158                               | IV               | [x+] <sub>4</sub> | Mercury's last appearance in the west in Leo                            | 126.912               | -0.817   |
| LBAT 1034-5 | Rev. 15  | 158                               | VI               | 5                 | Mercury's last appearance in the east in the end of Leo                 | 150.627               | 1.854    |
| LBAT 1127   | Rev. 7   | 158                               | [X]              | 12                | Mercury's last appearance in the east in Capricorn                      | 273.039               | -1.566   |
| LBAT 1127   | Rev. 8   | 158                               | [XI]             | 13                | Mercury's first appearance in the west in Pisces                        | 328.365               | -0.46    |
| LBAT 1038   | Obv. 20  | 172                               | V                | 2                 | Mercury's first appearance in the east in Cancer                        | 108.037               | -2.359   |
| LBAT 1134   | Obv. 9   | 178                               | V                | 20                | Mercury's first appearance in the east in Leo                           | 117.894               | -1.303   |
| LBAT 1134   | Obv. 12  | 178                               | VI               | 12                | Mercury's last appearance in the east in Leo                            | 145.564               | 1.864    |
| LBAT 1134   | Rev. 1   | 178                               | VIII             | 6                 | Mercury's first appearance in the west in Scorpio                       | 229.397               | -2.546   |
| LBAT 1134   | Rev. 2-3 | 178                               | VIII             | 23                | Mercury's last appearance in the [west] in the beginning of Sagittarius | 237.004               | -0.287   |
| LBAT 1136   | Obv. 6   | 179                               | V                | 10                | Mercury's last appearance in the east in Leo                            | 137.829               | 1.807    |
| LBAT 1135   | Rev. 2   | 179                               | XI               | 11                | Mercury's last appearance in the west in Pisces                         | 326.377               | 3.787    |
| LBAT 1137   | Obv. 7   | 183                               | III              | 3                 | Mercury's first appearance in the east omitted                          | 46.49                 | -1.758   |
| LBAT 1137   | Obv. 8   | 183                               | III              | 13                | Mercury's last appearance in the east omitted                           | 64.937                | 0.191    |
| LBAT 1137   | Rev. 4   | 183                               | VIII             | 29                | Mercury's first appearance in the west in Sagittarius                   | 255.891               | -2.052   |
| LBAT 1137   | Rev. 5   | 183                               | IX               | 14                | Mercury's last appearance in the west in the beginning of Leo           | 262.86                | 0.867    |
| LBAT 1137   | Rev. 6   | 183                               | IX               | 27                | Mercury's in the east first appearance in Libra                         | 248.718               | 3.36     |
| LBAT 1137   | Rev. 9   | 183                               | XI               | 10 <sup>2</sup>   | Mercury's last appearance in the east in the end of Capricorn           | 291.123               | -1.863   |
| LBAT 1137   | Rev. 11  | 183                               | XII              | 10                | Mercury's first appearance in the west in Pisces                        | 344.666               | -0.225   |
| LBAT 1047   | Line 15  | 184                               | X                | 5                 | Mercury's last appearance in the east in Capricorn                      | 278.402               | -1.677   |
| LBAT 1047   | Line 18  | 184                               | XI               | 7                 | Mercury's first appearance in the west in Pisces.                       | 334.406               | -0.211   |
| LBAT 1051   | Obv. 1   | 188                               | I                | 7                 | Mercury's first appearance in the west [in Tau]rus                      | 28.711                | 1.267    |
| LBAT 1051   | Obv. 8   | 188                               | II               | 13                | Mercury's last appearance in the west in Gemini                         | 66.033                | -0.947   |
| LBAT 1052   | Rev. 5   | 188                               | VII              | 30                | Mercury's last appearance in the east in Libra                          | 200.611               | 1.006    |
| LBAT 1051   | Rev. 11  | 188                               | X                | 20                | Mercury's first appearance in the east in Capricorn [...]               | 274.169               | 3.155    |

| Text        |            | Prediction date<br>(Seleucid Era) |                 |    |  | Tropical<br>longitude | Latitude |
|-------------|------------|-----------------------------------|-----------------|----|--|-----------------------|----------|
| LBAT 1055   | Obv. 8     | 189                               | II              | 4  | Mercury's [last appearance] in the west in Taurus                  | 46.136                | 0.859    |
| LBAT 1141   | Obv. 4     | 189                               | III             | 12 | Mercury's first appearance in the east in the end of Taurus        | 47.669                | -2.638   |
| LBAT 1055   | Obv. 23    | 189                               | IV              | 26 | Mercury's first appearance in the west in Leo                      | 126.88                | 1.211    |
| LBAT 1055   | Obv. 31    | 189                               | V               | 30 | Mercury's last appearance in the west in Virgo                     | 166.663               | -3.314   |
| LBAT **1055 | Obv. 37-38 | 189                               | VI              | 25 | Mercury's first appearance in the east in Virgo                    | 152.889               | -0.052   |
| LBAT **1055 | Rev. 43    | 189                               | VI <sub>2</sub> | 23 | Mercury's last appearance in the east in Libra                     | 184.736               | 1.364    |
| LBAT **1055 | Rev. 48    | 189                               | VIII            | 14 | Mercury's first appearance in the west in Sagittarius              | 262.33                | -1.99    |
| LBAT **1055 | Rev. 51    | 189                               | IX              | 2  | Mercury's last appearance in the west in Capricorn                 | 270.462               | 2.036    |
| LBAT 1055   | Rev. 52-53 | 189                               | IX              | 12 | Mercury's first appearance in the east in Sagittarius              | 259.091               | 3.503    |
| LBAT 1055   | Rev. 58    | 189                               | X               | 26 | Mercury's last appearance in the east in Aquarius                  | 299.731               | -2       |
| LBAT 1055   | Rev. 63    | 189                               | XI              | 27 | Mercury's first appearance in the west in Aries                    | 358.246               | 0.486    |
| LBAT 1057   | Obv. 18    | 194                               | IV              | 4  | Mercury in the east [...] first appearance                         | 72.932                | -2.223   |
| LBAT 1057   | Obv. 21    | 194                               | IV              | 23 | Mercury's last appearance in the east in Cancer                    | 103.999               | 1.456    |
| LBAT 1057   | Rev. 5     | 194                               | X               | 3  | Mercury's first appearance in the west in Capricorn                | 285.487               | -1.454   |
| LBAT 1057   | Rev. 6     | 194                               | X               | 20 | Mercury's [last appearance] in the west in Aquarius                | 297.885               | 2.585    |
| LBAT 1057   | Rev. 8     | 194                               | XI              | 8  | Mercury's first appearance in the east in Capricorn [...]          | 283.627               | 2.643    |
| LBAT 1149   | Rev. 5     | 198                               | X?              | 16 | Mercury's last appearance in the east in the end of Sagittarius    | 299.555               | -1.899   |
| LBAT 1059   | Obv. 2     | 201                               | I               | 2  | Mercury's first appearance in the west in Taurus                   | 27.679                | 1.045    |
| LBAT 1059   | Obv. 10    | 201                               | II              | 11 | Mercury's last appearance in the west in Gemini                    | 69.25                 | -1.116   |
| LBAT **1059 | Obv. 15    | 201                               | III             | 14 | Mercury's first appearance in the east in Gemini                   | 66.082                | -2.39    |
| LBAT 1059   | Obv. 20    | 201                               | IV              | 1  | Mercury's last appearance in the east in the beginning of Cancer   | 93.534                | 1.089    |
| LBAT **1059 | Obv. 26    | 201                               | V               | 5  | Mercury's first appearance in the west in Virgo                    | 155.093               | -0.035   |
| LBAT **1059 | Obv. 30    | 201                               | V               | 27 | Mercury's last appearance in the west in Virgo                     | 182.131               | -2.88    |
| LBAT **1059 | Rev. 37    | 201                               | VI              | 26 | Mercury's first appearance in the east in Virgo                    | 171.284               | 0.995    |
| LBAT 1059   | Obv. 37    | 201                               | VII             | 26 | Mercury's last appearance in the east in the end of Libra          | 204.855               | 0.827    |
| LBAT **1059 | Rev. 50    | 201                               | IX              | 13 | Mercury's first appearance in the west in Capricorn                | 277.62                | -1.727   |
| LBAT **1059 | Rev. 54    | 201                               | X               | 4  | Mercury's last appearance in the west in the beginning of Aquarius | 289.316               | 2.883    |
| LBAT **1059 | Rev. 70    | 201                               | XII             | 29 | Mercury's first appearance in the west in Aries                    | 17.575                | 1.106    |
| LBAT 1155   | Obv. 2     | 209                               | I               | 16 | Mercury's last appearance in the west in Taurus                    | 38.799                | -0.361   |
| LBAT 1155   | Obv. 4     | 209                               | II              | 19 | Mercury's first appearance in the east in Taurus                   | 42.598                | -2.814   |

| Text          |            | Prediction date<br>(Seleucid Era) |                    |                |   | Tropical<br>longitude | Latitude |
|---------------|------------|-----------------------------------|--------------------|----------------|---|-----------------------|----------|
| LBAT 1155     | Obv. 7     | 209                               | III                | 5              | Mercury's last appearance in the east in Gemini                               | 68.998                | 0.253    |
| LBAT 1153     | Obv. 8     | 209                               | III                | 29             | Mercury's first appearance in the west in the [...] of Leo                    | 116.768               | 1.582    |
| LBAT 1153     | Rev. 3     | 209                               | IX                 | 12             | Mercury's first appearance in the east in Sagittarius [...]                   | 261.867               | 2.833    |
| LBAT 1152     | Rev. 6     | 209                               | [XI <sup>2</sup> ] | 2              | Mercury's last appearance in the east in the beginning of Aquarius            | 294.937               | -1.908   |
| LBAT 1062     | Obv. 6     | 212                               | III                | 21             | Mercury's last appearance in the west in Cancer                               | 111.211               | -3.008   |
| LBAT 1160     | Obv. 3     | 233                               | II                 | 22             | Mercury's last appearance in the west in the beginning of Cancer              | 86.753                | -2.6     |
| LBAT 1160     | Obv. 5     | 233                               | III                | 22             | Mercury's first appearance in the morning in the end of Gemini                | 80.649                | -2.068   |
| LBAT 1160     | Obv. 10    | 233                               | VI                 | 1              | Mercury's first appearance in the east [error for west?] omitted <sup>2</sup> | 191.232               | -2.463   |
| LBAT 1160     | Obv. 12    | 233                               | VII                | 5              | Mercury's first appearance in the east in Libra                               | 185.678               | 1.576    |
| LBAT 1160     | Rev. 4     | 233                               | [IX <sup>2</sup> ] | 21             | Mercury's first appearance in the west in Capricorn                           | 290.971               | -1.42    |
| LBAT 1160     | Rev. 7     | 233                               | [X]                | 28             | Mercury's first appearance in the east in the beginning of Aquarius           | 291.885               | 2.348    |
| LBAT **1167   | Obv. 7     | 234                               | IV                 | 1              | Mercury's last appearance in the east in the beginning of Gemini              | 85.185                | 0.489    |
| BM 32247      | Rev. 3     | 234                               | IX                 | 18             | Mercury's first appearance in the west in Capricorn                           | 262.716               | -2.133   |
| BM 32247      | Rev. 7     | 234                               | X                  | 8 <sup>2</sup> | Mercury's last appearance in the evening in the beginning of Aquarius         | 287.132               | 2.951    |
| LBAT 1165     | Rev. 9     | 234                               | XI                 | 28             | Mercury's last appearance in the east in Aquarius <sup>2</sup>                | 311.867               | -2.146   |
| LBAT 1174     | Obv. 3     | 236                               | II                 | 6              | Mercury's first appearance in the east omitted                                | 30.7                  | -2.984   |
| LBAT 1174     | Obv. 4     | 236                               | II                 | 20             | Mercury's last appearance in the east omitted                                 | 53.065                | -0.612   |
| LBAT 1174     | Obv. 5     | 236                               | III                | 15             | Mercury's first appearance in the west in Cancer                              | 103.814               | 1.805    |
| LBAT 1174     | Obv. 8-9   | 236                               | IV                 | 23             | Mercury's last appearance in the west in the end of Leo                       | 151.486               | -3.284   |
| LBAT 1174     | Obv. 10    | 236                               | V                  | 21             | Mercury's first appearance in the east in Leo                                 | 137.993               | -0.047   |
| LBAT 1174     | Obv. 11-12 | 236                               | VI                 | 12             | Mercury's in the east last appearance in Virgo                                | 164.095               | 1.831    |
| LBAT 1174     | Rev. 1     | 236                               | VIII               | 8              | Mercury's first appearance in the east (error for west) in Sagittarius        | 249.159               | -2.255   |
| LBAT 1174     | Rev. 2     | 236                               | VIII               | 23             | Mercury's last appearance in the west in Sagittarius                          | 257.247               | 0.484    |
| LBAT 1174     | Rev. 3     | 236                               | IX                 | 7              | Mercury's first appearance in the east in Sagittarius                         | 242.976               | 3.276    |
| LBAT 1174     | Rev. 6     | 236                               | X                  | 23             | Mercur last appearance in the east in Capricorn                               | 292.528               | -1.963   |
| LBAT 1174     | Rev. 8     | 236                               | [XI]               | 23             | Mercury's first appearance in the west in Pisces                              | 346.538               | 0.307    |
| LBAT 1174     | Rev. 9-10  | 236                               | XII                | 27             | Mercury's last appearance in the west in Aries                                | 3.422                 | 1.421    |
| LBAT *1179-80 | Obv. 5-6   | 245                               | III                | 22             | Mercury's last appearance in the west in 'Cancer' <sup>1</sup>                | 109.289               | -2.646   |
| LBAT *1179-80 | Obv. 8     | 245                               | IV                 | 22             | Mercury's first appearance in the east in Cancer.                             | 99.229                | -1.573   |
| LBAT *1179-80 | Obv. 10    | 245                               | V                  | 12             | Mercury's last appearance in the east in Leo                                  | 127.579               | 1.751    |

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| LBAT *1179-80 | Obv. 13    | 245                               | VII  | 5               | Mercury's' [first appearance in the west omitted                    | 209.647               | -2.597   |
| LBAT *1179-80 | Obv. 13-14 | 245                               | VII  | 15              | Mercury's last appearance in the west omitted                       | 218.65                | -2.759   |
| LBAT *1179-80 | Rev. 15-16 | 245                               | VIII | 8 <sup>?</sup>  | [Mercury's] first appearance in the east in the end of Libra        | 203.685               | 2.476    |
| LBAT *1179-80 | Rev. 17    | 245                               | IX   | 10 <sup>?</sup> | Mercury's last appearance in the east in 'Sagittarius'              | 238.141               | -0.153   |
| LBAT *1179-80 | Rev. 20    | 245                               | X    | 17 <sup>?</sup> | Mercury's first appearance in the west in 'Aquarius'                | 299.026               | -1.61    |
| LBAT *1179-80 | Rev. 24    | 245                               | XII  | 20+x            | Mercury's last appearance in the east in 'Pisces'                   | 323.966               | -1.963   |
| LBAT *1181    | Obv. 3     | 246                               | II   | 8 <sup>?</sup>  | Mercury's first appearance in the west in Taurus.                   | 46.509                | 1.548    |
| LBAT *1181    | Obv. 5     | 246                               | III  | 15              | Mercury's last appearance in the west in Cancer                     | 90.256                | -1.701   |
| LBAT *1181    | Obv. 12    | 246                               | VI   | 29              | [Mercury's] first appearance in the west omitted.                   | 194.955               | -2.592   |
| LBAT *1181    | Obv. 15    | 246                               | VII  | 1               | [Mercury's] first appearance in 'the east' in Libra.                | 188.544               | 1.52     |
| LBAT 1182     | Obv. 5     | 247                               | III  | 12              | Mercury's first appearance in the east in Gemini                    | 65.987                | -2.643   |
| LBAT 1182     | Obv. 6     | 247                               | III  | 28              | Mercury's last appearance in the east in Gemini                     | 90.159                | 0.776    |
| LBAT 1183     | Rev. 3     | 247                               | IX   | 3               | Mercury's first appearance in the west in Capricorn                 | 250.286               | -1.486   |
| LBAT 1183     | Rev. 6     | 248                               | X    | 26              | Mercury's last appearance in the west in Capricorn                  | 269.451               | 0.573    |
| LBAT 1183     | Rev. 12    | 248                               | XII2 | 24              | Mercury's last appearance in the west in Taurus                     | 42.135                | 2.649    |
| LBAT 1188     | Obv. 4     | 300                               | II   | 17              | Mercury's last appearance in the west in Gemini                     | 63.285                | 0.007    |
| LBAT 1188     | Obv. 6     | 300                               | III  | 23              | Mercury's first appearance in the east in Gemini                    | 61.979                | -2.388   |
| LBAT **1191-2 | Obv. 3     | 303                               | V    | 23              | Mercury's first appearance in the east in Cancer                    | 118.77                | -1.001   |
| LBAT 1195     | Obv. 3     | 305                               | II   | 3 var: 5        | Mercury's first appearance in the west in the beginning of Gemini   | 50.193                | 1.603    |
| LBAT 1195     | Obv. 5     | 305                               | III  | 13              | Mercury's last appearance in the west in Cancer                     | 94.463                | -2.326   |
| LBAT 1195     | Obv. 7     | 305                               | IV   | 16              | Mercury's in the east in [...] first appearance                     | 89.165                | -1.295   |
| LBAT 1195     | Obv. 9     | 305                               | V    | 2               | Mercury's last appearance in the east in Cancer                     | 113.64                | 1.504    |
| LBAT 1195     | Obv. 12    | 305                               | VI   | 21              | Mercury's first appearance in the east (err for west), omitted      | 193.765               | -2.22    |
| LBAT 1195     | Obv. 13    | 305                               | VII  | 5               | Mercury's last appearance in the west omitted                       | 206.644               | -3.065   |
| LBAT 1195     | Obv. 14    | 305                               | VII  | 17              | Mercury's last (err for first) appearance in the east in Libra      | 201.998               | -1.127   |
| LBAT 1194     | Rev. 7     | 305                               | X    | 12              | Mercury's first appearance in the west in the beginning of Aquarius | 294.141               | -1.49    |
| LBAT 1195     | Rev. 6     | 305                               | XI   | 21              | Mercury's first appearance in the east in in Aquarius               | 298.493               | 1.927    |
| LBAT 1195     | Rev. 9     | 305                               | XII  | 25              | Mercury's last appearance in the east in Pisces                     | 331.566               | -2.4     |
| LBAT 1195     | Rev. 12    | 305                               | XII2 | 29              | Mercury's first appearance in the west in Taurus                    | 38.126                | 1.555    |
| MM 86.11.354  | Obv. 2     | 342                               | I    | 23              | Mercury's (first appearance in the east in Aries)                   | 15.044                | -3.205   |

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| MM 86.11.354 | Obv. 3  | 342                               | II  | 15              | Mercury's [last appearance in the east in Aries]    | 53.548                | 0.064    |
| MM 86.11.354 | Obv. 8  | 342                               | V   | 11 <sup>2</sup> | Mercury's first appearance in the east in Leo       | 126.528               | -0.739   |
| MM 86.11.354 | Obv. 9  | 342                               | VI  | 1 <sup>2</sup>  | Mercury's last appearance in the east in Virgo      | 151.481               | 1.886    |
| MM 86.11.354 | Rev. 3' | 342                               | IX  | 12              | Mercury's last appearance in the east in Capricorn  | 280.57                | -1.75    |
| MM 86.11.354 | Rev. 5' | 342                               | X   | 8               | Mercury's first appearance in the west in Capricorn | 273.622               | -1.445   |
| MM 86.11.354 | Rev. 6' | 342                               | XI  | 9               | Mercury's first appearance in the west in Pisces    | 329.061               | -0.711   |
| BM 45982     | Obv. 1  | 355                               | I   | 16              | Mercury's first appearance (in the east) in Aries   | 15.819                | -3.314   |
| BM 40083     | Obv. 3  | 372                               | II  | 12              | Mercury's last appearance in the west in Gemini     | 70.357                | -1.393   |
| BM 40083     | Obv. 8  | 372                               | V   | 10              | Mercury's first appearance in the west in Virgo     | 161.125               | -0.425   |
| DCT          | Obv.5   | 385                               | III | 12              | Mercury's first appearance in the east in Gemini    | 71.558                | -2.069   |
| DCT          | Rev. 1' | 385                               | IX  | 5 <sup>2</sup>  | Mercury's first appearance in the west in Capricorn | 272.433               | -2.062   |
| DCT          | Rev. 7' | 385                               | XII | 26              | Mercury's first appearance in the west in Aries     | 20.127                | 1.018    |

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